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# SCHOOL SCIENCE AND MATHEMATICS

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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XXI, No. 2 FEBRUARY, 1921 WHOLE No. 175

## CONTRIBUTION OF BIOLOGICAL SCIENCES TO UNIVERSAL SECONDARY EDUCATION.[1]

BY OTIS W. CALDWELL.

*The Lincoln School of Teachers College, New York*

Your program committee evidently desired to direct attention for a time to the question of what essential contributions there are which specific subjects of study may make to the proposed universal secondary education. We cannot justify universal secondary education, unless we can cite worthy universal uses to which the added school years shall be given. Such worthy and universal uses cannot be shown to a questioning public merely by general argumentation, but the values must be shown in the outcomes in worthwhile content and in power derived from specific subjects of study and specific enterprises in which secondary pupils may engage. The emphasis is shifted, therefore, from the easily written story concerning the extent and nature of illiteracy, ignorance and inefficiency, to the story which is much harder to write concerning the specific constructive measures which may remove illiteracy, ingorance and inefficiency. It has often been forcefully and truthfully stated that the commonwealth cannot either socially or economically afford to tolerate ignorant and inefficient citizens; but we dare not be so forceful because we cannot always be quite so clearly accurate when we attempt to show how certain pieces of subject-matter may surely operate in conferring scholarly and effective civic living.

The biological sciences are selected for illustrations, with no thought that they are preeminently important as sciences, nor that the sciences are more important than certain other fields of knowledge, but that this is the field in which the speaker can best cite illustrations. It is highly important that other fields of knowledge shall be presented also, in order that we may see the kinds of considerations which we think should contribute to universal secondary education. Furthermore, we do not possess

[1]An address given before the general meeting of the Illinois High School Conference in November, 1920.

either the data or the technique for securing adequate data to prove conclusively the place of biological sciences in universal secondary education. As in most other secondary fields we must deal with descriptive statements in the main, though there are available some acceptable proofs which are not as yet crowned with the statistical halo of our most worthy modern educational studies.

Our secondary schools now include enough pupils and pupils of sufficiently wide social and economic representation to give us a fair basis upon which to judge the kinds of problems which universal secondary education will present. If we include the seventh and eighth grades, which may or may not now be in junior high schools, it is safe to say we are now dealing with 4,000,000 secondary pupils in the United States. These come from parentage varying from those with almost four centuries of American life to those of but a few decades of life in America. They come from homes, ranging from palaces to box-like apartments which house several families in one suite of two or three rooms. They come clothed in the best that unlimited money can buy, to those silently suffering the elemental pangs of cold and hunger. They also represent the social, civic, economic and spiritual hopes of almost every country on earth, and universal secondary education cannot be adopted unless it can contribute to the needs of all, and at the same time conserve and develop individual needs. It would be a faulty education which would differentiate these pupils into school units which are designed to serve one or another of these groups of pupils. There is a genuine danger in a democracy, if the system of public education is avoided by those who can financially or socially afford the private school. It is significant to note that of the 15,266 persons who took the college entrance examinations board's examination in 1919, only 5,951 were public school pupils. Furthermore, since a smaller percentage of the public school pupils passed this examination successfully, it might be argued that public schools are doing poorer work, but it more probably means that the courses of study and methods of the two types of schools are organized and directed toward quite different ends. The situation cannot be adequately explained by the fact that many public school pupils enter college upon certificates, because the colleges to which the College Entrance Board recommends pupils, do not, in the main, accept pupils upon certificate. There is a very serious need of renewed attention to the possible social and intellectual results

of the renewed tendency toward sending certain types of pupils to private schools. However, it would be a faulty education which would raise the common educational level by filling the social and educational depressions of human kind by use of material secured by cutting down certain types of the race's elevations. Universal secondary education, if we are to have it, must give opportunity for individual ability and inclinations as well as purposeful education for all.

The period of American education in which we now are is one of unprecedented rethinking and new thinking in an effort to redirect and reform our materials and our procedures, so that if possible, American education may distinctively meet the problems of America. No other country ever undertook so seriously to give so much general education to all its people. No other large country ever had its population built up in a few generations by immigration or by the descendants of those of all nations, those who had courage, fortitude, foresight and convictions strong enough to cause them to come to a new land where the measure of their achievement might be found in their own strength and character, rather than in arbitrarily set limitations of some form of social or economic caste or of governmental restriction.

Unlike any other major peoples of the earth, we have organized an elementary school course of study of six years which we now generally require of all children. The requirement is not yet fully operative but is increasingly effective. We also have our high schools, four year, or junior and senior, but our judgment is unceratin as to how much of this period should be required of all.

Most students of secondary education incline toward the conclusion that the subjects of study should be all or almost all required for the junior high school period, grades seven, eight and nine; also, that the subjects of study for the senior high school grades should be essentially elective, by those who elect to attend the senior high school. It is a fair question for careful consideration whether this principle of required attendance should be carried to the senior high school, that is whether universal secondary education should apply only to that part of the high school in which the subjects of study are also required. This practice, if adopted, would be based upon the hypothesis that the junior high school includes those high school subjects which are requisite for the information, training, vocational and aesthetic outlook of all citizens. It is quite possible that the opportunities of the senior high school can be profitably used only by those whose

special interests and abilities lead them to desire the more specialized subjects of the senior high school. Indeed, it is not yet clearly demonstrated that all the subjects of the junior high school, certainly not all parts of some of these subjects, are so organized and so taught as to be necessary for the proper education of all junior high school pupils. Much less can it be shown that the more specialized subjects of senior high school are requisite for universal education of all youth of senior high school age.

Without desiring to be classed as one who opposes universal senior high school education, I wish to express the belief that it is hasty to ask for compulsory senior high school education until our subjects of study are more nearly organized so as to meet the universal needs of those whom we expect to attend these schools. We cannot as yet be too certain that all the junior high school subjects are so organized as to justifiy the requirement that all pupils shall study them. The subjects of study are being constantly though slowly improved, but it is socially, economically and educationally a gigantic and unprecedented proposition that we shall require all young people to remain in school through the whole high school course, and we may even lose ground by urging universally lengthened time requirements before we define more clearly the use to which the increased time shall be put.

In recognition of this great need the National Education Association established its Commission on the Reorganization of Secondary Education. This Commission consists of a general or reviewing committee, and numerous subsidiary committees, each subsidiary committee being charged with the study and reformulation, if necessary, of the proposed courses of study in a given field. The reviewing committee in cooperation with the chairmen of the subsidiary committees formulated and published a pamphlet called "Cardinal Principles of Secondary Education." After much consulation and study it was decided that the following seven main objectives are the outstanding things for which American Secondary education exists:

(1) Health;
(2) Command of fundamental processes;
(3) Worthy home membership;
(4) Vocation;
(5) Civic education;
(6) Worthy use of leisure;
(7) Ethical character. Obviously these objectives overlap, and obviously ethical character is not placed last because anyone

thinks it least important, for it is in all the others. It will be noted that these objectives relate directly to what the high school may do for its pupils, not to what are the essentials of the subjects of study. The essentials of a subject are those things which will meet these stated objectives. Please bear in mind that the committee does not favor less scholarship in the subjects of study, but rather that the truest high school scholarship is found in those things which contribute to these objectives. It is the firm belief of this commission that secondary education in the United States must aim at nothing less than complete and worthy living for all youth, and that therefore the objectives described herein must find place in the education of every boy and girl.

The committee on reorganization of the science in secondary schools has also completed its report, which is now being printed and copies of which are now available. This report has been over seven years in the making and is based upon hundreds of group conferences and many careful experiments. It is not the result of ordinary office committee work, but of trial under public school conditions, so that the recommendations made are already in operation in many of the best schools. The report is essentially a record of accomplishment, not prophetic appeal.

The general relation of science as a whole to these objectives may be stated as follows: It is important that those who are ill may be cured, but it is much more important that people be so taught that they may not become ill. The control and elimination of disease, the provision of adequate hospital facilities and medical inspection, the maintenance of the public health, all necessitate widely disseminated knowledge and practice of the basic principles of personal hygiene and public sanitation. It is the duty of the secondary schools to provide such instruction for all pupils. This purpose finds realization chiefly through science and civics. Therefore, health topics should be included in the science taught in the junior high school, and in at least the first two years of the four-year high schools.

Science touches the efficiency of the home and of life within the home at every angle. General science, biology, physiology, physics and chemistry all have definite services to render toward the proper organization, use and support of home life. A great vitalizing force for science instruction can be found in the relation of these courses to intelligent home-making, management and enjoyment. It is a serious criticism of science teaching in the past that these fundamental relationships have been so largely

overlooked. These relationships apply not only to those who have care of the home and of the children within it but also to such other members of the family as may be called upon to make repairs to the heating and ventilating system, to adjust the electrical appliances or to perform any of the many services that make for an effective home. Science has devised many conveniences that make the modern home comfortable and attractive, and science knowledge is required for their full appreciation and most intelligent use. These activities should be definitely related to better ideals regarding modern home life.

Science instruction should contribute both to vocational guidance and to broad preparation for vocation. In the field of vocational guidance such instruction should make many valuable contributions to a more intelligent understanding of the world's work and such an understanding should be so presented as to be of direct assistance in the wise selection of a vocation. Such knowledge should also impress students selecting certain vocations with the importance of making thorough and adequate preparation for their life work.

In the field of vocational preparation courses in shop physics, applied electricity, physics of the home, industrial and household chemistry, applied biological sciences, physiology and hygiene are of value to many students. Often a knowledge of the underlying principles increases the worker's enjoyment, helping him to think about and understand the processes with which he deals. Moreover, such knowledge and the interest aroused thereby may result in improving the work itself, and may result in invention for the improvement of the work of others.

The members of a democratic society need a far greater appreciation of the part which scientifically trained men and women should perform in advancing the welfare of society. Science teaching should therefore be especially valuable in the field of citizenship because of the increased respect which the citizen should have for the expert, and should increase his ability to select experts wisely for positions requiring expert knowledge. At the same time it should afford the basis for an intelligent evaluation of the services rendered by such experts.

Furthermore, the study of science should give a more intelligent appreciation of the services rendered to society by those who are engaged in vocations of a scientific nature and occupations based upon application of science. Such appreciation of the services rendered should lead to greater respect for the worker who renders the service.

Science opens the door to many useful and pleasurable avocations. For example, photography may be taken up by many but most intelligently by one who understands something of the nature of light, the action of lenses, the chemical changes involved in exposing, developing, and fixing plate and print. In the city and in the country, at the seashore, mountains, and elsewhere, nature is prodigal of her store of wonders. If the natural interest in these things has been developed and deepened by elementary courses in biology, botany, or zoology, not only is there added pleasure and enjoyment, but the door has been opened to wider interests and to a rapidly growing fund of valuable literature regarding science. The marvelous adaptations of plants to their environment, the march of plant progressions, the sharp competitions among the forms of animal and plant life, the history of the remote past record in the rocks are topics which mean much to one whose eyes have been opened by science instruction.

Trips to industrial plants to study raw materials, processes, and finished products, and visits to museums are means of developing life-long sources of enjoyment. To have avocational value, science courses should employ methods that can be used after school days.

Science study should assist in the development of ethical character by establishing a more adequate conception of truth and a confidence in the laws of cause and effect. Science, along with other studies that exalt truth and establish laws, should help develop sane and sound methods of thinking upon the problems of life. The problem of science are those of life, hence no quarrel regarding transfer of training need arise.

But more specific citations of service rendered must be given if any subject makes its case as an essential part of a required educational program. What are some types of biological topics which have a proved relation to the stated educational objections,or which may reasonably be expected to meet the objectives, or which we may readjust so that they may meet the objectives? It seems unwise to present a list or an outline of proposed topics in a reorganized course in biology. A few citations only can be included but they will be given in some detail, first, in order that their exact nature and import may be shown, and, secondly and more important, with the hope that persons who represent other secondary subjects of study may similarly cite type topics in their fields, as showing how those fields are expected to contribute

to universal secondary education. In each topic the facts of the case are presented first, then there is an indication of the educational result which has come or is expected to come from the use of the topic. We are not at this point speaking at all of method of presentation of these topics.

It is comparatively recently, indeed within the memory of many of us, when men learned that disease may be caused by the growth of small organisms, some plant and some animal. I can dimly recall the newspaper comments when Louis Pasteur and others asserted that disease may be transmitted by transmission of bacteria. Since that time, a spectacular development of useful biological knowledge has been made. People who are biologically intelligent no longer need be harrassed by some diseases, provided this knowledge has resulted in "the will to do," the intelligence and will to use the results of modern scientific knowledge. Whole commonwealths have voted funds and initiated campaigns against the mosquito, and an entire section of the country has found that intellectual achievement backed by an energized will power may hope to remove the hook-worm disease. At the time of his recent and lamented death, Major Gen. Gorgas was engaged in the first steps in no less a task than that of removing malaria and yellow fever from the earth. Almost every American community has been made conscious of important facts in the life cycle of certain mosquitoes. The race has endured the annoyance of mosquito bites for all time, for the bite is but temporarily disturbing, but malaria is not passed by so slightly. We know enough now to free any one or all of us from malaria, if we only will learn and act.

Much has been said and done in biological instruction concerning proper water and milk supplies. In most American communities there is now a distinct consciousness of the reasons for having pure milk and water. The study and control of the biology of the air-carried dust is a more difficult problem and it is possibly more important than the highly helpful study of the health relations of water and milk. It seems safe to say that advanced research in these fields in the next few years will find the study of the dust of the air very productive. It is now known that air may carry dust particles which are so small and are electrified in such a way that gravity alone would probably never cause them to alight upon the earth. Also, it is known that when the velocity of moving air is doubled, its power to carry

dust is increased 64-fold[2]. These dust particles are mineral and biological in origin, with the percentage of biological materials almost equal to the mineral. The biological materials have an abundant representation of living organisms, among which may be germs of tetanus, influenza, tuberculosis, etc. It may have been true that German sympathizers sold us court-plaster upon which germs of tetanus had been placed, but germs of tetanus may also be carried by dust-ladened air currents, and the possibility of presence of tetanus germs upon exposed gummy surfaces will continue in peace as in war. Indeed, the dried and pulverized excretions of animals compose a large part of the biological portion of wind-blown dust, and these particles are particularly favorable for transporting tetanus organisms. Tubercle bacilli may also be carried by currents of air, and notwithstanding the germicidal action of sunlight upon moist organisms, dessicated organisms are less affected by sunlight. There are undoubted cases of tuberculosis infection by the dust fron a room of a tubercular patient. As a matter of fact, tubercle bacilli are rarely absent from dust that is not moving, and in city streets they are common and most notable features of the disease-producing germ life. Many other organisms, both harmful and harmless, are known to be component parts of air-carried dust.

What has been accomplished or may be accomplished through biological education with materials such as those just cited? The practice of medicine is concerned chiefly with caring for those who are ill, or helping in educational campaigns in situations which have reached a critical point. It is the business of education, and primarily, though by no means wholly, of biological education, to instruct, convince and motivate the general public in matters of public health by use of biological facts and processes as they relate to community and individual health problems. Some of those present can remember a time when certain skin diseases, as the "itch," were regularly recurring disturbances. The "sulphur-and-lard" treatment which followed infection made life irksome and eventually unendurable to the organisms which caused the trouble, but neither the malady nor the "sulphur-and-lard" caused the unfortunate human being to suffer social ostracism. He was merely unfortunate. But when the community learned through its schools and otherwise that the disease bore a direct relation to filth, it soon became disgraceful for one to have

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[2]J. W. Redway, Mount Vernon, N. Y., "An Overlook of the Relations of Dust to Humanity." Ecology 1: 198, 192, 1920.

the "itch," and this knowledge and the accompanying social judgment created an attitude which made every home desire to eradicate the difficulty.

We have reached almost the same stage in social evolution regarding typhoid. It is a filth disease. Each individual cannot control his environment quite so effectively against typhoid, but the community, hence its individuals, will soon be conscious of social disgrace when typhoid emerges within it. This knowledge and consequent social judgment has greatly reduced and will some time eradicate typhoid. The same kind of information and judgments will some time remove tuberculosis and many other dreaded diseases. It is now announced on good authority that in its earlier stages tuberculosis is definitely curable. It is also readily preventable and but a few decades of universal education by use of knowledge already possessed, and new knowledge constantly being secured, would enable men to free themselves from the ravages of the "White Plague."

Another positive phase of this type of education is essential. For example, it is believed that most or all human beings have been infected with tuberculosis. Many have remained unconscious of the infection and have not suffered noticeably from it. This is because their bodies were in such healthful conditions that the germs, though beginning their growth, could not gain headway against a normally well nourished and efficiently working human body. This is but one of the very many ways of emphasizing the great importance of study and application of that phase of biology which deals with nutrition, growth and use of the human body. We now possess a middle-aged generation of human beings many of whom have enjoyed and benefited by biological instruction in nutrition and growth. It seems safe to assert that the extension of such instruction to all of the younger generation will yield a large return in preventing disease through maintenance of effectively working human bodies.

In its contribution to command of fundamental processes biological science is peculiarly rich, since it deals with life itself, of which pupils are a part. Possibly one of the best illustrations relates to the world's food supply—a topic as old as human life and likely always to be the center of pointed discussions. It has given many a teacher real pleasure to see a group of young people first catch the real meaning of chlorophyl work in green plants. Knowing that available foods are not limitless, and that hunger and starvation are the exponents of food shortage, a graphic

picture is seen when a young pupil first considers what would occur if for a single season the chlorophyll of plants would cease to operate. Over and over, for centuries and centuries, have units of carbon dioxide and water, returned from decaying plants and animals, been reabsorbed by plants, and made in the chemistry of the leaf again into carbohydrates, thence perhaps into proteids, and finally into protoplasm, only to break up and return again to the chlorophyl-plant, to begin again the round of carrying energy from the sunlight by means of chemistry and physics, so that life may proceed in its functions.

We were recently told that the wheat production of the United States in the ten year period 1909-1918 averaged 650,000,000 bushels per year more than the yearly average for the 10-year period 1849-1858. This means that men have learned how to direct the work of chlorophyll so that the world may have more and better bread. Each time we see an expanse of growing wheat or corn, we see an exponent of the progress of scientific knowledge of man's control of fundamental processes. No pupil who uses food is devoid of need for understanding such fundamental processes as these, and some pupils are thereby stimulated to desire to know more and to help direct such a gigantic food laboratory; others see the artistic or poetic setting of an essential industry; still others, who may later work in offices or factories, have gained an understanding of the kind of problem with which agriculturists, horticulturists and gardeners must deal, and finally there are some pupils who are fired by a desire to add more to what we know of such processes. Science is full of such illustrations of fundamental and universal processes which people need to know, both for their own direct use and for their understanding of the work in which others engage, and as a means of discovering the fields of their possible future scholarly enterprises.

As an illustration of science and civic life and responsibility, may I cite the fact that the increasing use of applied science has carried with it increasing obligations for public instruction and public care in order that increasing injuries and deaths may not follow. The history of inventions shows that the introduction of many beneficent contributions of applied science has been followed by an increase in injuries and deaths. The pocket knife but a few generations ago became a regular accompaniment of almost every boy and man, and cut fingers and injuries in combat were increased thereby; and more recently the aeroplane, the most spectacular and fascinating of modern inventions, is still so poorly

under control that there is a high degree of probability that any devotee of flying will sooner or later give his life as a sacrifice to this wonderful instrument of modern inventive science. The motorcycle is so destructive and so frequently a public nuisance that many good citizens can almost be convinced of the earthly presence of a Satanic Majesty whose embodiment appears in this noisy, ubiquitous, and fear-producing instrument. The automobile is less truly an object of scorn because almost all of us make use of it more or less frequently, but it is in total far more of a biological problem than is the motorcycle. It is stated[3] that in 1919 an average of 2 1-2 persons were injured and 1 killed by automobiles for each 1,000 inhabitants in the United States. This means an average of 1 1-3 persons killed for each hour of the whole year 1919. At the present rate there will be an increase of 10 per cent of killed and injured from this cause in 1920. Of these accidents 90 per cent occur in public highways. The fact that the percentage of increase of killed and injured does not quite keep pace with the percentage of increase of numbers of automobiles in use does not necessarily mean that we are educated to be more careful but may in part be due to the gradual or perhaps hasty elimination of those persons who do not readily learn the necessary lessons which accompany the advance of science. Possibly a combination of natural and artificial selection may be effecting a change in our social composition as relates to this question. If all of those in this audience who have driven automobiles for five years or more should report upon their personal accidents and injuries to themselves or families, we should doubtless find a high percentage of personal experience with the problem to which I am referring.

Obviously these questions are of great importance in the universal education of people who in any phase of living need to be protected against injury. Some one may say these matters are cared for by constant admonitions given to people younger than those in the high school. But mature citizens, in their personal care and, above all, in their discharge of civic duties, need an intelligence about these situations which surpasses admonition—indeed, which makes the correct basis for the admonitions which are given to younger persons. It may also be said that this topic properly belongs in the course in civics or possibly in some other social study. May I venture two assertions in reply. Biological studies for universal secondary education must be large-

[3]C. M. Talbert, St. Louis, Chairman Safety Section of National Safety Council.

ly social in their objective; and secondly, the true motivation of such a study comes not primarily through a knowledge of the laws regulating traffic, but through a keen sense of the life or biological significance of the situations to which these laws relate. However, it is not of fundamental importance whether such studies shall appear under the name of biological science or civics or any other particular subject which deals with adjustment to environment or adjusting environment to us, as it is that such studies shall appear definitely and effectively somewhere in any scheme of education which is designed for all pupils of high school age.

In closing this incomplete discussion may I express the opinion that we need universal secondary education through the junior high school period. Our concern need not be so great just now, however, as to whether we secure immediate legislation enforcing universal secondary education as that our subjects of study and our school procedures shall be so redirected and reformed that these subjects and procedures shall be surely worth while for all pupils of secondary school age. Difficult and slow as is progressive school legislation, much more difficult and slow are the processes of reorganization of school subjects and methods in the effort to make an increased school life really productive of the educational objectives which must be attained in American education. This is a task which is sufficiently important, fundamental and enduring to justify the most thoughtful efforts of all who by inclinations, training and ideals are willing to give themselves to it.

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## PLATINUM CONTINUED SCARCE IN 1919.

The United States is still dependent on foreign countries for its supply of platinum. The small output of crude platinum from domestic mines increased from 647 ounces in 1918 to 824 pounces in 1919, but the total quantity of refined platinum and allied metals recovered from foreign and domestic ores by domestic refiners decreased from 59,753 ounces in 1918 to 45,109 ounces in 1919. Only 11,759 ounces of refined platinum was derived from domestic ores in 1919. On the other hand, the imports of platinum and allied metals increased from 56,753 ounces in 1918 to 68,054 ounces in 1919, nearly half of which came from Columbia. The estimated world's production increased from 62,283 ounces in 1918, the lowest recorded output, to 67,180 ounces in 1919, but was still far below that of preceding years.

During the war 83 per cent of the platinum metals consumed in this country was used in essential industries (chemical, electrical, and dental), but in 1919 only 40 per cent was so used, and the quantity used for jewelry increased from 12 to 56 per cent. The remaining small percentage was divided among several minor uses.—[ *U. S. Geol. Survey.*

## STANDARDS FOR JUDGING AGRICULTURAL CLUB EFFICIENCY.

By W. W. Charters and James H. Greene,
*Formerly of the University of Illinois*

With the increased demand upon the part of the public that the school foster and support many of the extra-school activities of young people, school men have turned for help to the several agencies already organized and at work on different phases of this problem. Among the several movements which have enjoyed a certain measure of success in this respect is the boys' and girls' club work fostered and supported by the U. S. Department of Agriculture and the several state agricultural colleges. Until many school systems, county and city, had perfected organizations for carrying on garden and agricultural work, this was practically the only agency to which the school man could turn. Although with the development of the county farm bureau the active administration of club work in most cases has passed out of the hands of school authorities, school men are still represented in its counsels and interested in its success.

As in the case of most movements which were started to solve a particular problem whose success has led to rapid expansion, the aims and purposes of the movement have not been carefully defined. This condition led the writers to make this study.

In the fall of 1917 the writers started to make a scale for judging the efficiency of boys' and girls' clubs and now take the opportunity to report on their work. This is done, not because a scale has been perfected, but because of the startling lack of unanimity about the importance of items used in judging club efficiency.

In making the scale, the first step taken was to list a number of items which the writers presented to state club leaders with the request to add and eliminate such items as, in the opinion of the individuals consulted, were of importance in judging club efficiency. Upon the receipt of replies from state leaders, the following list of items was determined:

Table I. Items by Which the Efficiency of Boys' and Girls' Clubs May be Judged.

1. Evidences of cooperation among members, such as the *legitimate* "changing work" among members, giving and seeking advice from one another.
2. Ninety per cent of the club show some "labor income."
3. Ninety per cent of the club make a report.
4. A picnic, round-up, or field day for members of the club.
5. Evidences of club spirit.

6. Evidences of application by members of knowledge gained in club work to nonclub activities.
7. A regular corps of officers for the club.
8. A complete report of the work of the club to the County or State Leader.
9. Cooperative buying and selling in the club.
10. Evidences of friendships centering around the project.
11. Ninety per cent of the club complete project.
12. Fifty per cent of the membership desire to continue the work.
13. Regular meetings, at least once a month.
14. A public demonstration by the club, or by a team chosen from it, of some "doing" phase of its work.
15. Evidences of desire on part of members for further education centering around training in agriculture or home economics.
16. Ninety per cent of the club make an exhibit.

These items were then assumed to be the items by which club efficiency would be determined. The ninety per cent mentioned in items 2, 3, 11, and 16, and the fifty per cent in item 12, were obtained by taking the medians of replies to the question asking what per cent in each of these cases was considered to be satisfactory in each case.

This list of items was then sent again to all the state club leaders with the request to rank them in order of importance from most important to least important. The response was generous and from the total returns, 55 were found to be complete in every detail and were used to determine what was the composite opinion of the state club leaders of the nation.

It was hoped that some emphatic consensus would be revealed. But exactly the opposite occurred as is shown in Table II.

TABLE II.

Showing the rank given to each of the sixteen items by 55 state leaders (Items are arranged along the top and ranks along the left-hand margin):

| Rank | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | .... | 8 | .... | 1 | 3 | 5 | 2 | .... | 1 | 13 | 3 | 2 | 1 | 7 | .... |
| 2 | 1 | 1 | 8 | .... | 2 | 8 | 1 | 7 | .... | 2 | 9 | 5 | 7 | .... | 9 | 1 |
| 3 | 8 | 4 | 8 | 1 | 6 | 5 | .... | 9 | 2 | 2 | 8 | 6 | 2 | 2 | 7 | 4 |
| 4 | 5 | 4 | 3 | 2 | 3 | 1 | 1 | 4 | 1 | 3 | 2 | 3 | 2 | 3 | 2 | 3 |
| 5 | 2 | 1 | 5 | 1 | 4 | 3 | 7 | 3 | .... | 4 | 2 | 10 | 7 | 7 | 3 | 5 |
| 6 | 3 | 6 | 3 | 1 | 2 | 3 | 2 | 4 | 1 | 1 | 5 | 3 | 4 | 5 | 3 | 5 |
| 7 | 2 | 3 | 4 | 5 | 3 | 5 | 4 | 3 | .... | 1 | 3 | 4 | 3 | 6 | 2 | 4 |
| 8 | 3 | 3 | 2 | 4 | 7 | 4 | 8 | .... | 1 | 2 | 2 | 3 | 4 | 5 | 3 | 2 |
| 9 | 3 | 4 | 5 | 7 | 8 | 3 | 2 | 4 | 3 | 5 | 2 | 5 | 3 | 3 | 1 | 3 |
| 10 | 3 | 2 | 3 | 4 | 3 | 2 | .... | 3 | 4 | 4 | 2 | 1 | 1 | 2 | 2 | 4 |
| 11 | 3 | 4 | 2 | 7 | 2 | 6 | 4 | 6 | 4 | 2 | 4 | 3 | 5 | 6 | 3 | 6 |
| 12 | 3 | 2 | 1 | 12 | 4 | 1 | 6 | 2 | 3 | 4 | .... | 3 | 6 | 4 | 3 | 6 |
| 13 | 2 | 6 | 1 | 2 | 4 | 2 | 5 | 1 | 7 | 4 | 3 | .... | 6 | 4 | 1 | 4 |
| 14 | 3 | 7 | 2 | 4 | 3 | 4 | 6 | 2 | 9 | 6 | .... | 4 | 2 | 2 | 6 | 1 |
| 15 | 4 | 1 | .... | 3 | 1 | 3 | 1 | 3 | 12 | 7 | .... | .... | 1 | 4 | 3 | 4 |
| 16 | 3 | 7 | .... | 2 | 2 | 2 | 3 | 2 | 8 | 7 | .... | 2 | .... | 1 | .... | 3 |

In this table, the items listed in Table I are arranged across the page and their rankings are arranged in the vertical columns. For instance, item number one, cooperation among members, was ranked as of most importance by five persons, second, by one person, third, by eight persons, etc. (Where items were judged to be equal they were given an average ranking, as when items 4 and 12 were judged to be equal and next below rank 5 they were given a rank of 6.5, the average of 6 and 7. In this case they appear as rank 6 in Table II.)

This table reveals the startling fact that every item used in judging club efficiency received every possible ranking with only a few exceptions. For instance, item one, cooperation of club members, was given first place in importance by five persons, second by one and sixteenth by three. If there were perfect agreement in opinion 16 of the 256 spaces would have been filled. If there were maximum disagreement the 256 would all be filled. As a matter of fact 235 of the spaces are filled.

It is startling because it shows that there is no national aim of pronounced importance in agricultural club work. No one aim and no group of aims predominate in importance. It would be supposed, as the writers expected, that some of these would definitely predominate. The literature of the Department of Agriculture stresses some more than others and the opportunities for occasional conferences should develop some of the unanimity which is not apparent in the returns. Federal domination is certainly not apparent in the field of club objectives.

It was quite as interesting to note that the leaders in the states which sent in more than one reply were also lacking in agreement as to the aims of club work in each particular state. A typical state which sent in four replies ranked the items as follows in Table III.

TABLE III.

Showing rankings given each item by the four leaders reporting from one state (Items are shown along the top, judges in the left-hand margin):

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 13 | 5.5 | 12 | 9 | 2 | 11 | 5.5 | 14 | 9 | 7 | 2 | 4 | 15.5 | 2 | 15.5 |
| 2 | 3 | 14 | 7 | 13 | 9 | 1 | 16 | 6 | 4 | 10 | 8 | 11 | 15 | 5 | 2 | 12 |
| 3 | 2.5 | 15 | 2.5 | 8 | 6 | 2.5 | 16 | 11 | 10 | 9 | 6 | 6 | 14 | 13 | 2.5 | 12 |
| 4 | 9.5 | 16 | 1 | 11 | 15 | 9.5 | 5.5 | 3 | 13.5 | 13.5 | 2 | 5.5 | 4 | 7.5 | 7.5 | 12 |

This shows that judge one gives first place to items 6, 12, and 15, judge two to item 6, judge three to items 1, 3, 6, and 15, and judge four, to item 3. Judge two gives second place to item 15

and third to item 1, while judge four gives second place to item 11 and third to item 8. Thus the first three most important ranks include no item common to all the leaders in one state. Item 6 is common to three of the four, and item 3 is common to two, but items 1, 8, 11, 12, and 15 are also given high rank by only one leader each.

It would seem, therefore, that there is no unanimity about the ends to be obtained by state leaders either in the individual states or in the nation, although there is somewhat more agreement among leaders in the same state than among the different states.

In working with the data to see what approximate agreement appeared, the median rank for each item as shown in Table I was obtained. The device was also used for finding how often each item was included in the first, second, third, and fourth ranks. And the additional device was used of finding what per cent of the judges judged each item to be better than item 9 which was found to be the least important item. These are listed in Table IV.

TABLE IV.

Showing number of judges placing each item in each four ranks from 1 to 16, showing median rankings and per cent of judges who adjusted each item as better than item 9:

| Items | 1st | 2d | 3d | 4th | Median | Per cent better than 9 |
|---|---|---|---|---|---|---|
| 1 | 19 | 10 | 12 | 14 | 8 | 73 |
| 2 | 9 | 13 | 12 | 21 | 10 | 67 |
| 3 | 27 | 14 | 11 | 3 | 5 | 87 |
| 4 | 3 | 11 | 30 | 11 | 11 | 67 |
| 5 | 12 | 16 | 17 | 10 | 8 | 71 |
| 6 | 17 | 15 | 12 | 11 | 7 | 67 |
| 7 | 7 | 21 | 12 | 15 | 8 | 80 |
| 8 | 22 | 10 | 15 | 8 | 6 | 78 |
| 9 | 3 | 2 | 14 | 36 | 14 | .... |
| 10 | 8 | 8 | 15 | 24 | 12 | 53 |
| 11 | 32 | 12 | 8 | 3 | 3 | 87 |
| 12 | 17 | 20 | 12 | 6 | 6 | 85 |
| 13 | 13 | 18 | 15 | 9 | 8 | 84 |
| 14 | 6 | 23 | 15 | 11 | 8 | 74 |
| 15 | 25 | 11 | 9 | 10 | 5 | 84 |
| 16 | 8 | 16 | 19 | 12 | 10 | 69 |

Table IV should read as follows: Item 1 was judged by 19 leaders to be in ranks 1, 2, 3, or 4; by 10 leaders to belong to ranks 5, 6, 7, or 8; by 12 to belong to ranks 9-12; and by 14 to belong to ranks 13-16. It has a median rank of 8 and was judged to be better than item 9 by 73 per cent of the judges.

This information is shown in another form in Table V. Here

it is found that if the item judged to be better than item 9, cooperative buying and selling, by the most judges, is placed first in rank and the others arranged in order of the number judging each as better, items 11 and 3 are given first place, 12 is given third place and so forth. If the median rank as determined from Table 1 is taken as a basis and the item which has the highest median rank is placed first, item 11 is given first place, and items 3 and 15 are next and equal in rank and so on. It is found in the third line of the table from the facts found in Table IV, that if the number of judges which give each item first, second, third, or fourth rank is counted and the item receiving the highest vote is given first rank, item 11 comes first, and item 3 second rank, etc. Finally, if the number of judges who gave each item the ranks of thirteenth, fourteenth, fifteenth, or sixteenth are added as found in Table IV and the item receiving the smallest vote is given first rank and that receiving the largest vote the sixteenth rank, items 11 and 3 are judged to be equal and highest and item 9 lowest.

### Table V.

Showing items arranged in order of importance by four standards:

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent better than 9 ranking.. | 11 | 3 | 12 | 13 | 15 | 7 | 8 | 14 | 1 | 5 | 16 | 2 | 4 | 6 | 10 | 9 |
| Median rank'g.. | 11 | 3 | 15 | 8 | 12 | 6 | 1 | 5 | 7 | 13 | 14 | 2 | 16 | 4 | 10 | 9 |
| Frequency of 1–4 ranking | 11 | 3 | 15 | 8 | 16 | 12 | 13 | 5 | | 2 | 10 | 16 | 7 | 14 | 4 | 9 |
| Frequency of 13–16 ranking | 11 | 3 | 12 | 8 | 13 | 5 | 15 | 4 | 6 | 14 | 16 | 1 | 7 | 2 | 10 | 9 |

### Conclusions Concerning a Few Items.

From these figures the statement may be made that items 11, (90 per cent completing the project), and item 3, (90 per cent making a report), are considered to be of most importance in general. It is also found that item 9, cooperative buying and selling, and item 10, club friendships, are regarded as of least importance. Item 10 ranks higher in line three, but obviously line three is of more value in placing items of higher rank than of low rank. Beyond these four items little can be said about any marked consensus of opinion and even in these cases it must be remembered that items 11 and 3, which here receive first rank, are ranked as least important by some judges and items 9 and 10, receiving lowest rank in this table, are judged as of relatively high value by some judges.

### A Significant Question.

These facts reveal such a lack of agreement of aims in boys' and girls' club work that the question arises as to the advisability of the leaders reaching some agreement about what the proper function of the club is. It may be that the purpose of the appropriation made by the Federal Government may be achieved in various ways and it is certain that the clubs can achieve many purposes other than these mentioned in the enabling act. And it may be, also, that this noticeable lack of agreement is desirable in the sense that each leader or group of state leaders ought to be left to set his own aims deliberately arrived at. But the suspicion cannot be allayed that this wide variety of aims is not the result of deliberation so much as the result of failure to deliberate. One is inclined to believe that state leaders have given little attention to the question of what results they shall labor to achieve. It is obvious that some policy of determining club aims should be developed.

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## QUICKSILVER PRODUCED IN THE UNITED STATES DURING THE SECOND QUARTER OF 1920.

From April 1 to June 30, 1920, inclusive, 3,685 flasks of quicksilver of 75 pounds net, was produced in the United States, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior, who obtained the figures from the producers. This is 1,214 flasks less than was produced in the first quarter of 1920 and 255 flasks less than was produced in the second quarter of 1919. Only 13 mines, were reported as productive—8 in California, 1 in Nevada, 1 in Oregon and 3 in Texas. California produced 2,704 flasks, Texas 952 flasks, and Nevada and Oregon together 29 flasks.

The average monthly price of quick-silver per flask in San Francisco for the quarter, as quoted in the Mining and Scientific Press, was $100 in April, $87 in May, and $85 in June. The average price for the quarter was therefore about $91 as compared with about $86 for the first quarter.

The chief cause of the decrease in production during the second quarter was the destruction by fire, on June 20, of the reduction plant of the New Idria mine, in California, and the consequent loss of quicksilver already reduced during the earlier part of that month. Because of this misfortune the production for the third quarter of 1920 will probably be still smaller than that for the second quarter. Reconstruction is in progress, and it is expected that the plant will be in partial operation in August or September of this year. Other causes that contributed to the decrease in production were a shortage of efficient labor and a reduction in the average grade of the ore.

At a time when initiative in the quicksilver-mining industry is at a low ebb and the tendency is rather to abandon enterprises already begun than to embark on new ones it is of interest to note that the formerly productive Klau mine, in San Luis Obispo County, Calif., has been reopened under very capable management as the Carson mine, and that its 50-ton furnace has been put in repair, so that the mine is likely to become a considerable producer.—[*U. S. Geol. Survey.*

## TEACHING THE FUNDAMENTALS IN CHEMISTRY.

BY B. S. HOPKINS,

*University of Illinois.*

The teaching of elementary chemistry has always been a difficult task because of the inherent complexity of the subject. It matters little where we begin our study or what method of attack is selected, complications are soon encountered from the natural interdependence of the principles and phenomena studied. As a consequence of the involved nature of the subject, no student can be expected to master all of the material presented in a textbook by a single journey through its pages. In fact, it is perhaps the usual thing to find that the teacher of chemistry is adding constantly to his own fund of knowledge through discussions and varied viewpoints, even though he may teach many generations of students from the same book.

Within recent years this natural difficulty in teaching chemistry has been greatly increased by the fact that certain scientific discoveries have made it necessary to revise some of our most fundamental conceptions of the science. These new developments have resulted mainly from various studies of radioactivity and the behavior of matter under greatly diminished pressure. As a result of these changes in our fundamental theories, new complications have been introduced, and for the most part these new notions are exceedingly bewildering to the beginner. It is no wonder then that the teacher of chemistry is at a loss to know just how much of this "new chemistry" he should include in his teaching; for well he knows that if he attempts to include all the newly discovered facts he may produce utter confusion in the minds of his pupils. On the other hand, if these new conceptions are ignored, he is not keeping abreast of the times in his rapidly developing subject and he may soon discover that he has been left hopelessly behind.

Many elementary textbooks attempt to develop in the mind of the beginner a difference between chemistry and physics by establishing a distinction between a chemical change and a physical change. It is doubtful if such a procedure is ideal. For, in most cases, as an example of a physical change is given the melting of ice and the condensation of steam. In later years the student is assured that the latter phenomenon is pretty certainly a case of polymerization which may, at least in part, be represented by the equation $3H_2O \rightleftarrows (H_2O)_3$. When the student

[1]Read before the chemistry section of the University of Illinois Conference with affiliated schools, Nov. 19, 1920

compares this reaction with the one representing the polymerization of acetylene, a phenomenon which is most certainly chemical in its nature, he finds a similar equation applies: $3C_2H_2 \rightleftarrows (C_2H_2)_3$.

Grave doubt arises if the student is asked to believe that one represents a physical change and the other a chemical change. If it is necessary to distinguish between physics and chemistry, it may be done much more certainly by considering the former as dealing with energy and its changes, while the latter has to do with changes in the composition of matter.

The chemistry textbook of a quarter of a century ago gave many definitions, but there seems to be a well-defined tendency among present day authors to avoid set definitions of chemical fundamentals. This tendency is probably due to two reasons: (1) it is very difficult to formulate a definition which is brief, clear, comprehensible and at the same time true to scientific fact; (2) beginning students are especially given to memorizing the words of a definition and are frequently able to repeat the words perfectly while they do not have the slightest conception of the meaning of the sentences. To avoid these difficulties many of the recent authors discuss the fundamental conceptions of chemistry, give illustrations, but leave to the student the construction of the definitions. This process requires thought, understanding and a command of English which may be considered "education" in the true sense of the term. When any concept in chemistry is discussed as fully as circumstances permit, it is possible to convey a much more accurate idea concerning it than if we rely on a brief definition. Consequently, I believe that one of the most useful plans for teaching modern chemistry is to avoid as far as possible set definitions and to insist on explanations in the student's own words, with illustrations to make sure that the meaning is clear.

As an illustration of the difficulty of giving definitions, notice the definition of an element given in the Third Edition of A. W. Stewart's "Recent Advances in Physical and Inorganic Chemistry," p. 240. "The following definition of an element appears to cover practically all the ground: An element is a form of matter which has (1) a definite atomic weight; (2) a definite spectrum; (3) a definite valence or electrical charge; (4) a definite series of chemical properties; (5) a resistance to any ordinary chemical reaction such that no decomposition of the material into anything simpler is possible; and (6) in certain cases, a

definite series of radioactive properties. If any form of matter agrees with all these criteria, we are justified in assuming that it is chemically elemental in character." Most of us will agree that this definition is conservative, comprehensive and as satisfactory as it is possible to formulate. Yet if we examine it closely we find some distinct opportunities for criticism. The recent work of Harkins, in Chicago, and Aston, in England, shows pretty conclusively that chlorine, for instance, does not have a definite atomic weight but it is a mixture of two isotopes of atomic weights 35 and 37. Judged by this definition, iron is not an element, because in place of having "a definite spectrum and a definite valence or electrical charge," it has two distinct valences whose solutions, known as ferrous and ferric, have different spectra and very different chemical properties, one resembling magnesium, the other suggesting aluminum. By this same definition nitrogen is not an element because the recent work of Rutherford seems to indicate that when nitrogen is bombarded by alpha particles its molecules yield hydrogen.

A definition of this sort would not only fail to help the beginner to grasp the meaning of the term element but it would certainly produce confusion and uncertainty of mind.

In the presentation of a complicated conception it is doubtful if an attempt should be made to develop the entire idea at one time. The first mention of a fact may be made as simple as possible, then later additions may be made to this idea and perhaps after several references have been made in cycle form the full theory may be developed. To illustrate by the use of the conception of oxidation: While the student is studying oxygen he learns that oxygen unites with phosphorus and that this important process is an example of oxidation. Later, when chlorine is studied, he learns that phosphorus burns in chlorine as readily as it does in oxygen and that the two phenomena are of the same general nature. Hence, the union of phosphorus and chlorine is also oxidation, though no oxygen is involved. Still later, other phenomena are encountered which give a still broader view of oxidation and finally the student is ready for the general statement that any raise in valence is oxidation. If objection is made to this method of treatment because the instruction is fragmentary and always more or less uncertain, a word from the instructor will relieve this situation. When the subject is first introduced the student may be warned that there will be additions made to the statement later; on the second mention of the

subject the teacher may recall the first conception and prepare the student mind for still later additions, while at the last recurrence of the topic the whole matter may be reviewed thoroughly for the final impression which is desired.

In like manner the difficulty with the conception of the element may be settled. If it is impossible to frame a definition of the term element which will be both simple and scientifically accurate, it seems much more satisfactory to use the old simple conception, with the addition that the thought is not complete. Then when radioactivity and subatomic phenomena are studied, it is possible to modify the original conception as much as may be required.

Until quite recent times the atom was generally considered as an extremely small particle of matter compact in form, spherical in shape, homogeneous in character, unchangeable, indivisible, and indestructible. There were as many kinds of atoms as there were members of the list of elements and an atom of one element had little in common with atoms of the other elements. How completely these simple ideals have been overthrown! In place of this ultimate unit of matter we are now forced to believe that atoms resemble miniature solar systems, each one made up of a positive nucleus about which the electrons rotate in orderly fashion, following definite orbits. If the atom is magnified until it is a mile in diameter, the electrons would be about as big as baseballs while the nucleus would be as large as a pinhead. Yet this pinhead would contain over 99 per cent of the total weight of the atom. So an atom is not a compact unit of matter but mostly empty space. We are also led to believe that the electrons are alike in all atoms, that an electron may easily be detached from one atom and add itself to some other atom which may differ fundamentally from the mother atom. The arrangement of the electrons in the members of the zero group is so stable that no method has yet been discovered by which an electron may be removed or added. On the other hand, the atoms of the radioactive elements are so unstable that they are continually shooting themselves to pieces, giving off relatively large groups of electrons which are recognizable as being identical with other atomic arrangements. To ask a beginner in the study of chemistry to grasp this complicated conception of the unit of matter would, in my humble opinion, be a most tremendous blunder. I believe it would be far better at first to give him the old original idea of the simple unchanging

atom, with the thought that at some later time we might be able to break open this shell which seems to be solid and examine its structure, behavior and relationships. I do not believe that we expose our teaching to the charge of being unscientific if we develop a complicated conception in this manner. For we are simply following the natural course of mental development, since in these easy steps the human mind has advanced from the simplest conceptions of the ultimate nature of matter to our present complicated theories.

Until a few years ago a crystal of common salt was considered as an orderly arrangement of molecules, each one of which contained a certain atom of sodium and a definite atom of chlorine. Recent work has shown that while a given crystal of sodium chloride undoubtedly contains the same number of sodium atoms and chlorine atoms, no one sodium atom can claim any particular chlorine atom as its own companion. Each sodium atom is to be thought of as surrounded with chlorine atoms and each chlorine atom is surrounded by sodium atoms, but there is no tendency toward arrangement in pairs. In spite of this fact, I believe the beginner should be taught that a molecule of salt is composed of an atom of sodium and an atom of chlorine. In later years, when the student learns from his study of physical chemistry that this is not the whole story, he will realize that the original statement is not a scientific untruth but an attempt to develop by easy steps a conception which is difficult for the advanced student and next to impossible for the beginner.

There are many important conceptions in modern chemistry which I do not believe the beginner should be taught at all. The structure of atoms, the electrical theory of valence, the existence of isotopes and isobares, the quantum theory and others of this nature do not appeal as essential to a fundamental course in chemistry. If this is true, then these topics should not be introduced by the authors of textbooks or the teachers of chemistry. But what shall be done with the matter if the student himself raises the questions? Suppose, for example, in the discussion of the term element the statement is made that an element cannot be decomposed into simpler forms of matter nor synthesized from other things. One thoughtful student has been reading in his science paper that radium, an element, decomposes into helium and niton. He promptly raises the questions: Why is radium considered an element if it is decomposed? Why is it not regarded as a compound of helium and niton? Such ques-

tions as these should be answered frankly, in as simple language as possible and with the best scientific information available. If I were asked such a question by one of my own students I would say that while radium does disintegrate it is regarded as an element because (1) it has a definite spectrum, (2) it behaves like an element in that it conforms to the laws of definite proportions and multiple proportions, (3) the change is not to be considered as a case of decomposition in the ordinary sense because the rate of change is not affected by the highest temperature or the greatest cold, (4) the energy liberated is vastly greater than is obtained from any known chemical reaction and this change is accompanied by the emission of charged particles which is not common to chemical changes. Hence, this change is not the same as an ordinary chemical decomposition but is to be considered as taking place within the atom itself.

There is perhaps one grave danger in this method of teaching our complicated theories and that is that we may be accused of teaching half truths. I do not believe this trouble will become serious if the teacher takes pains to teach chemistry as a live subject which is growing rapidly as the weeks pass. Students are prone to accept the word of their teacher or their textbook as final and it is difficult to convince them that the subject is constantly undergoing rapid development. One of the best ways to get a student of elementary chemistry to realize that the subject is advancing is to refer frequently to what may be expected from a further study of the subject. So if the teacher introduces a conception in a simple form with the warning that more may be expected later, there is little danger that the student will feel that he is being taught part truths or that his course is scientifically unsound.

# HOW MAY LOCAL INTEREST IN CHEMISTRY BE INCREASED?[1]

By C. E. Osborne,

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There is a local chemistry of vital interest which no textbook can give, which few teachers know and fewer teachers teach. Take advantage of this to interest your community in chemistry.

Having built up a chemistry department in a so-called classical and literary community from an enrollment of seven to one hundred and sixty, a department that has grown five times as fast as the school, and in which we have almost as many pupils studying chemistry as all the other advanced sciences—including botany, zoology, physical geography and physics—combined, I may be pardoned for offering the following suggestions on how to increase the local interest in chemistry.

I. Lectures to pupils on "Some Interesting Chemical Experiments," "Soda Water," "The Air We Breathe," "The Water We Drink," "The Food We Eat," "The Clothes We Wear."

II. A series of practical experiments on "Tests for Food Constituents," "Water Analysis," "Milk Analysis," "Tests for Adulterants in Foods," "Soap Making," "Testing Cloth Fibers," followed by a written report on investigations made at home on foods, cloth and labels on canned goods, in place of the regular monthly tests.

III. A board of food inspectors who purchase foods in the local market and test them under my supervision and hand me written certified reports of their findings.

IV. Lectures before boys' clubs, mens' clubs and women's clubs on timely topics as "Adulterants in Foods and Simple Kitchen Methods for Their Detection," and lectures before student bodies on such subjects as "Science and Warfare," "How Chemistry Helped to Win the War."

V. Articles in the local papers on "Our Local Food and Milk Supply."

VI. An annual chemistry exhibit or open house.

VII. Visits to a model bakery, a model dairy and a modern ice plant.

VIII. Large display cards on the laboratory walls with such inscriptions as the following:

The chemistry pupil is not so easily duped by fake "dopes" and fake "docs."

The chemist has run the food fakir to earth.

A knowledge of chemistry is an aid to good health.

By applying chemistry Rockefeller saw millions in crude petroleum oil.

Soap that makes the whole world clean contributed by chemistry.

Baking power, the leaven of civilization, a product of chemistry.

Millions saved annually because chemistry gave us the fire-extinguisher.

Disinfectants to stop the spread of contagious diseases and anaesthetics to make possible the most delicate and difficult operations, produced by chemistry.

Every tint of the rainbow for dyeing fabrics and clothing given us at little cost by chemistry.

This splendid building is possible because of chemistry. It has contributed the concrete in the foundations and walls, the brick, cement and iron lath, the tile of the roof, the copper drains and down-

[1]Read before the chemistry section of the High School Conference at the University of Illinois, Nov. 19, 1920.

spouts, the steel beams and girders, the glass for the windows, the mosaic tiling for the floors, the iron and brass bolts and screws, hinges, locks, electrical fixtures, tinting for the walls, paint for the woodwork and the heat that makes it comfortable.

IX. A bulletin board on which are posted photographs of noted living scientists, articles taken from magazines and newspapers, jokes, cartoons—almost anything pertaining to chemistry or the value of an education. This is not only chemistry up-to-date but chemistry up-to-the-minute.

X. A serious attempt to show the applications of each day's lesson to industry and everyday life—a serious attempt to vitalize chemistry.

To put new life into old chemistry you must not only know chemistry and love to teach chemistry but you must also live your chemistry. The pupil will catch your enthusiasm and will realize that it is a privilege to know, that it is a wonderful world in which he lives; that the world was not built by chance. He will understand the world better and will therefore be the better fitted to live in it; his mind will be on things worth while, and to him finding out will be fun and work will be living.

But I have been asked to tell you especially about our chemistry exhibit or open house. Through public lectures, newspaper articles and the pupils I had succeeded in taking the chemistry department to the parents, but I wished further to bring the parents to the chemistry department that they might have a more definite and intimate knowledge of it and therefore take a more personal interest in it.

The English department caught the attention of the community through the annual public class play, the music department through the annual opera, the athletic department through football, but the attention of the public was never definitely directed toward other departments. I suggested that indoor athletics, manual training, household arts, the art department and all the sciences unite in a public exhibit or keep open house. I knew that the parents would come for one if not for the other and while we had them there we knew they would look in on the chemistry department and we prepared to have something for them to look at when they looked. Between five hundred and one thousand people were present at our first exhibit and the next year saw an unusual increase in the number of pupils enrolled in the chemistry department. The exhibit has been repeated several years with the same marked success.

As soon as one exhibit is over I begin to think of and plan for the next. To succeed with anything it must be uppermost in one's mind. If, when you get an idea, you put it down on paper and carry that paper with you so that it is always at

your finger's end, you will have plenty of material when the time comes. It is best to give the exhibit toward the end of the school year when the pupils are more skilled in laboratory work and have a better working knowledge of chemistry. The experiments are taken largely from the regular work, but enlarged, perfected and made practical. Special effort is made to introduce things of local interest.

Just before one of our exhibits it was reported that at a banquet held in Chicago some one had put arsenic in the soup and most of the guests were poisoned. One of my pupils made some soup, put arsenic in it, tested for, and found it. At the exhibit he showed and explained his results, but I did not let him make the experiment in the presence of the guests because of the danger involved. Testing cigarettes for nicotine and the papers for arsenic and arranging an apparatus to smoke the cigarette are always of great interest to the boys and this demonstration does more good than a lecture on cigarette smoking.

It is better to develop some definite subject.

At our last exhibit the subject was "Some Applications of Chemistry to the War." I chose this because it was uppermost in people's minds. "Practical Applications of Chemistry," "Some Applications of Chemistry to Industry," "Some Interesting Chemical Experiments," "Chemistry in the Home" are topics we have had. I begin to talk to the pupils about this at least one month before the date of the exhibit and post a suggested program on the board. I ask them to add anything they think would be good and, if approved by me, I let it go on the program. There are always some interesting and valuable suggestions. One boy suggested an exhibit on bacteria as he expected to be a physician. He gave a most interesting and commendable demonstration of bacteria responsible for contagious diseases and handled the microscope with unusual skill in preparing slides for the guests. A girl suggested an exhibit on the composition of man in which we should have bottles containing samples of the elements in man and the exact amount in the average body of one hundred and fifty pounds in weight. This proved to be very interesting and instructive. Another pupil designed and constructed a large, original and successful working model of Hiero's fountain. It ran for two hours or more and with a jet at least two feet high and could be varied at will. Another prepared a case of radiographs and photomicrographs. He made a cabinet for them electrically lighted and placed it

permanently on the laboratory wall. One day when a boy fell and broke his wrist this boy made an X-Ray plate of it for the doctor which distinctly located the fracture. Another was testing a sample of vinegar to find the per cent of acetic acid when suddenly he gave a scream. He had taken his burette where there was a good light to get an accurate reading when he discovered that it was alive. There were millions in it. We soon had them under the microscope and then we used the projection lantern to throw them on the screen. You can imagine the excitement. He had discovered the vinegar eel.

I ask those who are willing to be responsible for certain topics to write their name after it and I always have more volunteers than I have room to allow to take part. This gets the pupil to do the thing in which he or she is interested and they gladly read and spend extra time on their topic. Of course, they must talk it over with me and be sure that their experiment is a success or it cannot go on the program. On a separate sheet of paper for each I write all the questions which I can think of that any visitor might ask them and they must be certain that they can answer these questions. A card explaining what the pupil is doing is tacked at the top of his desk. A printed program and a hygrometer calendar is handed to each visitor as he arrives. This exhibit is given at night.

The following points about the exhibit should be emphasized:

I. More than five hundred persons came to the exhibit where not more than four or five visit the regular recitation and laboratory work during the year.
II. It is interesting to the teacher as well as the pupil and I learn more from it than the pupil. It helps to keep one out of the rut.
III. It gives a number of boys and girls an opportunity to show their ability who do not ordinarily take part in public affairs or athletics.
IV. It acquaints the community with the splendid equipment and facilities of the chemistry department.
V. It impresses the public with the practical value of chemistry.
VI. The pupils take pride and pleasure in doing and explaining these things and a new and practical interest in chemistry is awakened.
VII. Parents and teacher meet under most favorable conditions.
VIII. It increases the enrollment materially.
IX. The best things that have ever been said in the public press about me and my work have been said by those who visit this exhibit. The value of such unsolicited praise in its influence on the community is immeasurable.

Of course this is advertising but it certainly is legitimate and it gets results.

CHEMISTRY EXHIBIT, 1915.

This is an attempt to give you an idea of the work done and a demonstration of how it is done.

LECTURE ROOM.

I. The list of experiments recorded in the top row to the right as you enter shows the list of experiments made by each pupil during the

year. (Each pupil makes eighty experiments and analyzes twenty unknowns.)

II. Below the experiment records are reports on investigations made at home, including the interpretation of labels on canned package and bottled goods and the testing of cloth fibers, etc.

III. Above the north blackboard are colored charts showing the relative amounts of food values in the most common foods.

IV. The analysis of milk collected from Oak Park wagons.

This analysis is in charge of Kent Early, assisted by Robert Helmle and Brice Barber.

LABORATORY.

Pupils are working as they do in regular laboratory work. Each experiment presented tonight has been made by every pupil.

I. Making nitric acid.
II. Testing candies.
III. Testing vinegar.
IV. Analyzing water.
V. Testing extracts, coffee, butter.
VI. Weighing a hair.
VII. Making hydrogen—a constituent of water.
VIII. Making oxygen—the other constituent of water.
IX. Testing foods for food value.
X. A study of bases.
XI. Making soap.
XII. Making ammonia.
XIII. Making bromine.
XIV. Testing cloth fiber.
XV. Finding the percent of wool in a piece of cloth.
XVI. The distillation of wood and coal.
XVII. Analyzing unknowns.
XVIII. Making carbon dioxide, the gas in soda water.
XIX. A study of hard waters.
XX. Making hydrochloric acid.
XXI. Distilling water.
XXII. Analyzing tooth powders.
XXIII. Testing sausage, hamburger, dried apricots, peaches, apples, and pears.
XXIV. A study of saturated solutions.

The Hiero fountain was designed by Fleetwood Albright and constructed by Fleetwood Albright and Kenneth Birkin.

The siphon fountain was also constructed by Birkin and Albright.

The exhibit on "The Composition of Man" was prepared by Elizabeth Fuller.

The microphotographs and radiographs and the exhibition case in which they are displayed is an original piece of work by Harvey Morrow.

1916.

LECTURE ROOM.

I. The analysis of milk from Oak Park dairies is made by Walter Blount and Marshall Wilson.

II. Fire extinguishers are demonstrated by Gordon Hurst and Chauncey Grainger.

LABORATORY.

1. Arsenic in cigarette papers and nicotine in the tobacco.
2. An inexpensive, automatic still.
3. Alcohol in patent medicines.
4. Can you hard boil eggs and cook potatoes on Pikes Peak?
5. Convection currents in water when heated.
6. The manufacture of illuminating gas.
7. To compare the quantities of gas given off by different brands of baking powder.
8. Methods of extracting oils.

9. Making corn syrup from starch.
10. Making and distilling alcohol. The yeast plant.
11. Various ways to dye cloth.
12. Making library paste.
13. Photography.
14. How we know the composition of the sun.
15. Crystals.
16. Writing with electricity.
17. Testing cotton, silk, wool and linen.
18. Making soap.
19. Separating water into hydrogen and oxygen.
20. Chlorine, the gas used in gas bombs.
21. The ammonia fountain.
22. As the microscope sees it.
23. An acetylene gas plant.
24. Etching designs on glass.
25. Glass blowing.
26. Silver and copper plating.
27. What makes them go?
28. Some simple interesting experiments.

1917.

LECTURE ROOM.

I. Above the north board are colored food charts showing the relative amounts of food value in the most common foods.

II. The manufacture of illuminating gas from soft coal demonstrated by Arthur Jones and George Madill.

LABORATORY.

Pupils are working as they do in regular laboratory work.

1. Detecting arsenic in soup.
2. Acetylene gas.
3. Nicotine in cigarettes.
4. Phosophorus from match heads.
5. Silver plating.
6. Alcohol in patent medicines.
7. Testing candies.
8. Testing vinegar.
9. Analyzing water.
10. Testing estracts, coffee, butter, etc.
11. Making hydrogen, a constituent of water.
12. Making oxygen, the other constituent of water.
13. Testing foods for food value.
14. Making soap.
15. Ammonia, the cleaning agent.
16. Bromine, for gas bombs.
17. Chlorine, for gas bombs.
18. Testing cloth fiber.
19. Carbon dioxide, the gas in bread and soda water.
20. Hydrochloric acid, the acid in the stomach.
21. Distilling water.
22. Testing hamburger, dried peaches, pears, apples, etc., for sulphur compounds.
23. Neutralizing an acid by a base.
24. Radium.

A demonstration of photographic work by Charles Hudson and Thomas Hildebrand.

Some studies of bacteria by George Wantz.

An exhibit of the composition of man.

MARCH 14, 1919.

Theme: Some applications of chemistry to the war.

RECITATION ROOM.

Here will be found many souvenirs and trophies of the war which the young people will be glad to show and explain to you.

LABORATORY.

The pupils will demonstrate the following and will be pleased to answer your questions.

1. Signal lights, smoke screens, star shells, James Quigley.
2. Oxygen for the pulmotor, oxygen helmet and oxy-welding, Arthur Matthews.
3. Hydrogen for balloons and oxy-hydrogen blow torch, Genevieve Hipp.
4. Filling toy balloons with hydrogen, Douglas Gordon.
5. Matches used 100 years ago, Laurence Mills.
6. The electrolysis of salt, (lye, chlorine and hydrogen), Willard Vaughn.
7. Chlorine for gas warfare, bleaching, and for purifying water, Thomas Empey.
8. Soapmaking (glycerine for nitro-glycerine), Roy Farwell.
9. Bromine for gas warfare, Miles Stybr.
10. Nitric acid for nitro-glycerine, dynamite and smokeless powder and T. N. T., Lawton Tabor.
11. Sulphuric acid for nitro-glycerine, dynamite and smokeless powder, David Johnson.
12. Gunpowder, Earl Larsen.
13. Ammonia for nitric acid and as refrigerant, Munson Emery.
14. Saltpeter for gun powder and fertilizer, Ormand Lyman.
15. Iodine to reduce swellings, antiseptic in operations, Marion Hall.
16. Ether as anaesthetic in surgical operations, Lester Lloyd.
17. Chloroform, anaesthetic in surgery, Howard Root.
18. Fulminate of mercury to discharge explosives, Frederick Hart.
19. What the boys had to drink in France, Gerry Bates.
20. The composition of man, William Cary.
21. Fire extinguishers, dry, wet, pyrene, Arthur Lomas.
22. Sensitive ink used by spies and for telling fortunes, Florence Shafer.
23. Photography, John Huff.
24. The electrolysis of water, hydrogen for balloons, oxygen for helmets and welding, John Phillips.
25. Testing vinegar, vinegar eels, Ruth Macauley.
26. Testing cloth, cotton, silk, wool, linen, Gladys Watts.
27. Silver plating, Kathryn Ratcliff.
28. Radium for radiolite watches (dark room), Norris Gathercoal.

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## AN EXPERIMENT TO DETERMINE THE DRIVING TORQUE OF AN AUTOMOBILE.[1]

BY H. C. KRENERICK,

*North Division High School, Milwaukee, Wis.*

If an automobile or chassis is accessible to members of a physics class, the following problem will prove to be very interesting and practical.

Power equals Force x Velocity (ft. per minute)

Horsepower equals Force x Velocity divided by 33000

Neglecting the loss in transmission, the power of the engine will be the same as the power of the driving or rear wheels. If the last equation is used to determine the horsepower developed at the tires of the rear wheels, the force factor is the push exerted by the rear tires against the road. This push is known as the "trac-

[1]Read before the Physics Section C. A. S. & M. T. Chicago, November 26, 1920.

tive effort" or "driving torque." This torque may be determined from the equation if the horsepower and velocity are known.

The maximum horsepower of the engine may be obtained from the specifications of the car, or by applying the S. A. E. formula:

Horsepower equals diameter squared x number of cylinders divided by 2.5.

A more accurate determination could be made by using the complete formula:

Horsepower equals Pressure (90 lbs.) x Area x Piston speed (ft. per minute) x number of cylinders x Efficiency (.75) divided by 4 x 33000.

The piston speed may be taken as 1,000 feet per minute or computed from the stroke and speed of the engine when producing maximum power. The speed of highest efficiency may be obtained from the manufacturer.

If the transmission gears are placed in "high" or direct drive, the loss in transmission from engine to rear wheels is considered to be 10 per cent. The velocity in feet per minute of the outer surface of the rear tire may be determined from the circumference and the number of revolutions per minute. When in "high" gear the crank shaft of the engine is connected directly to the propeller shaft, consequently the only reduction in speed is in the differential.

Count the number of teeth in the ring gear and in the drive pinion gear of the differential. From the speed of the engine, the gear ratio, and the circumference of the tire compute the velocity of the tire. Substitute the horsepower and velocity of the tire as determined above in the horsepower equation and solve for the force or torque. Divide this by 2 to find the push at each wheel.

In a like manner determine the torque when in each of the remaining gears: Intermediate, low and reverse. The loss in transmission in each of these speeds is 15 per cent. It is greater because of transmission through the countershaft. To determine the velocity at each speed or gear, the number of teeth in all gear wheels involved in the transmission from crank shaft to propeller or shaft must be counted. To do this remove the top of the gear set box.

If an automobile is to be used instead of a dissectible chassis, the final gear ratio or the number of revolutions of the crankshaft of the engine to one revolution of the axle shaft may be obtained by jacking up the rear wheels and using the starting crank.

# THE BEARING OF RECENT RESEARCH ON THE TEACHING OF ELEMENTARY PHYSICS.[1]

By Henry Crew,

*Northwestern University, Evanston, Ill.*

1. In the eulogy which Arago pronounced before the French Academy upon James Watt, the eminent Scottish engineer, he says that "clearness in public speakers is politeness." And since I heartily concur in this characteristic French precept and believe that definitions are very clarifying, I propose, first of all, to define the term "elementary physics" as I shall use it, namely, a presentation of the fundamental facts, principles, and method of that group of sciences which deals with the transformations of energy and matter. But this, of course, might well cover the entire field of physics and chemistry, pure and applied, mathematical and experimental. Let us then use the adjective "elementary" to delimit the subject still further and say that we shall discuss the teaching of physics only, excluding chemical phenomena (which generally involve change of composition), and including only so much ground as is ordinarily covered in a high school course or in a first year course in college: in other words, a brief, but wide, study of mechanics, sound, heat, light, electricity and magnetism.

2. In addition to this definition, I will assume that we are all agreed that each student who goes through a course of elementary physics—whatever may be the peculiar views of the instructor—should come out with a fair grasp of, and a working knowledge of, those general principles and phenomena which have been found to control the operations of the physical world. Merely to interest the young man is not enough, merely to dazzle him with brilliant experiments or to have him talk glibly about recent research or to be familiar with recent research—none of these is enough if he has not grasped the fundamental ideas of Newton, the energy principle, the concepts of temperature and potential, the properties of waves, and some of the other fundamentals.

3. If we are agreed on this limitation, perhaps we can also agree further that if the teaching of elementary physics is not affected by modern research, it is absolutely unique as the one subject not so affected. A few years back research was prosecuted by the gifted few, working either in their own private laboratories, as did Joule and Huggins and the late Lord Ray-

[1]Read before the Physical Science Section, University of Illinois, High School Conference, November 19, 1920.

leigh, or in academic laboratories, as did Helmholtz, Maxwell and Rowland. I am not unmindful of such exceptions as Faraday and Lavoisier working in public or semi-public institutions—but they were truly exceptional.

Nowadays, however, "everybody's doing it"; the government, the large corporation, the manufacturer, the instrument maker, the teacher who is looking for academic promotion—all with a deliberate purpose; and in addition, the man who is engaged in research because he can't help it, the man to whom nothing else is half so interesting, the man who considers the discovery of a single simple fact the most worthwhile thing he can do.

This deluge of results has brought about a new attitude of mind in nearly every class—the buyer is even uncertain as to how large a stock he may lay in, remembering the rapidity with which processes change; the maker is not certain as to how large a stock he should produce in view of certain improvements reported from his research department; your doctor takes you into his confidence and tells you that this new medicine has not yet been tried in a sufficiently large number of cases for him to give you an accurate percentage of cures and failures; a motor car two years old is out of date; when you reprimand your son for visiting with the girls till one o'clock in the morning, he calls you a "fossil"; when you upbraid him for his discourtesy, he informs you that your system of ethics is outworn and that he and "all the other boys" are traveling according to new and recently discovered rules of the road.

So I say a science of physics that had not been touched by research would be what these same boys politely denominate "stone age stuff." But is there any such physics? There may be. I can only say I have not seen it.

4. Did you ever stop to think that the time was when it could be said concerning any phenomenon in physics—even the simplest—that its explanation is a matter of recent research? The invention of the chariot wheel, the production of fire, the detection of the motion of the planets among the stars must each, at some prehistoric period, have been a recent discovery of compelling interest. Time was, of course, when men did not know how far a floating vessel, say, a Greek vase, would sink in the water; but some two centuries B. C. this was a matter of recent research when Archimedes proved that in order to determine how far a trireme will settle into the water when launched you

have merely to compute the depth of a body of water which has the same external shape and weight as the hull of the trireme. Time was when men did not know how vision was accomplished by the human eye. In the seventeenth century—as late as the time of Kepler—it was a matter of recent research that the retina is the screen upon which the crystalline lens produces an optical image. Sometime between the period of Chaucer and Milton, it was a recent discovery, made by Benedetti, that the proper measure of torque is the product of the force by the perpendicular distance from the axis to the force; the bent lever was then clearly explained. Cannon were brought into the field by the English for the first time at the battle of Crecy in 1346. But it was more than a couple of centuries later that Galileo first showed how to compute a trajectory; and this was made possible only by one of his recent researches, namely, the discovery of the laws of bodies falling freely at the surface of the earth; and this a half century later made it possible for Newton to test the behavior of the moon and discover whether it falls toward the earth according to same laws as a cannon ball. The agreement was poor—but a recent research by Picard and others on the size of the earth, enabled Newton to correct his results and prove the inverse square law to the satisfaction of every one.

It was about this same time (1669) that the explanation of the pull on the string which a boy experiences when he is whirling a body about his head was first explained by Huygens. In this recent research, he distinguishes for the first time between mass and weight—calling the former the "solid quantity" (solides quantitates) of the body whirled. The term mass which Newton defines on the first page of the *Principia* is based directly upon the then recent research of Huygens.

Well, one might go on in this manner indefinitely, or at least until he had covered the entire field of physics.

5. I now come to my final thesis, which is this: Since all of physics was at some time or other a matter of research, why not present it in this manner from the very start and avoid giving the young man the impression that physics is a closed chapter? Why not present these inspiring examples of men who, early and late, devoted their lives to research, and point out at the same time that it is but a short distance from where we now are in elementary physics to the borders of the unknown. From the junior laboratory to the front line trenches of research is but a

stone's throw. There is no such thing as finality at any point in physics.

The simplest of experiments—such, for example, as that of weighing—when pushed to a little higher degree of accuracy becomes tremendously complicated. The late Lord Rayleigh is said to have once remarked that the most difficult experiment he ever undertook was the comparison of two weights, namely, the weight of oxygen in a certain glass bulb compared with the weight of hydrogen required to fill the same bulb under the same conditions of pressure and temperature.

So one finds it whenever he attempts to measure, with a little more than ordinary accuracy, a temperature, a wave length, a resistance, or any other physical quantity. In attempting to go a little farther, one almost instantly reaches the unknown. For illustration, let us consider the gas law. Here one has only to go back to the civil wars of England to reach a time when practically nothing was known about how volumes vary with pressure. Robert Boyle is a most inspiring man to present to students. The extension of Boyle's Law by Charles and Gay Lussac to meet the case where the temperature of the gas is not constant; and the still further extension of this law by van der Waals[2] to cover the cooling effect studied by Joule and Thomson, as well as the more accurate measures of Amagat, bring one up to the recent attempts of Onnes and others, described in his splendid volume on the *Equation of State*, Vol. 11 of the *Leyden Communications.* One of the pending problems of physics today, if I am correctly informed, is the proper equation of state with which to describe the behavior of ammonia gas. The Linde device for making liquid air has added tremendously to the importance of the term $a/v^2$ for elementary physics. From another point of view, all these laws may be presented as a consequence of the kinetic theory of gases. Newton says, "If I have seen farther than Descartes, it is by standing on the shoulders of giants."

Let us consider another very trite topic—that of energy. In the days when Descartes and Leibnitz were disputing as to whether mv or $\overline{mv}^2$ was the proper measure of energy (i. e., in the days before it was clear that force is the time-variation of one of these expressions and the space-variation of the other) this topic was indeed a very live one. But now that the equal merits of *momentum* and *vis viva* have been established, the best minds in

[2] $(p-a/v^2)(v-b)=RT$ where the symbols have their usual meaning.

science are not lying awake nights over the question. Indeed, it is only a few years ago, 1847, that we were set straight in this matter of energy. One of the men who was most prominent in setting us straight was here in Illinois only a few years ago. I refer to Helmholtz.

On the other hand, many facts which, up to a certain date, have been of trifling importance, have in the light of recent research assumed enormous importance. The residue left over in Cavendish's eudiometer tube when he had finished sparking the nitrogen and oxygen into nitric acid was an important fact only in the sense that any fact is important, especially when it is not understood; but it acquired additional importance on the discovery of argon. The current which Edison got from his two-electrode vacuum tube (as we now call it) was for a long while a fact of minor importance. No one would so estimate it at present. The discrepancy between the density of nitrogen taken from the atmosphere and nitrogen artificially prepared was a matter of small importance until the accuracy of weighing had been pushed to the point where the difference for these two nitrogens was greater than the error of weighing.

The upshot of the whole matter is that in order to evaluate the importance of physical facts one must more or less—the more the better—keep abreast of modern investigation.

It is equally important to keep in touch with recent laboratory devices. In the days when Sir Humphry Davy and Faraday and Joseph Henry were covering their wire by hand, wire covered by machinery would have been a distinct blessing—even more than our enamelled wire is today. My memory of the first portable ammeter I ever saw is still very distinct—it was in 1884, when "webers" had just been converted into "amperes." "Graded galvanometers," as such instruments were then called, were matters of recent research. And when one considers the laborous processes of current measurement which they replaced, he realizes that it was a matter of some importance for every teacher of physics, in those days, to be *en rapport* with recent research.

6. μηδεν'αγαν said the Greeks—the first great thinkers of Europe: *ne quid nimis,* the Romans; which, being interpreted, means, *not too much of anything:* in other words, it is easy, in our teaching, to run even research into the ground. How shall we draw the line? My criterion is this: *Use anything from any source that will help to make clear the fundamental prin-*

*ciple which you are demonstrating. But don't drag anything in merely because it is new.*

Nothing gives a healthful student more pleasure than to get a clear grasp of something which has hitherto been hazy to him. If, therefore, one's topic is fundamental and is clearly put, he need not worry about "interest." A student is always "interested" in that upon which he grows. But above all, avoid giving him the impression that physics is a completed volume—a finality.

A concrete illustration will make my meaning clearer: A few years ago Professor Porter of University College, London, showed that in lagging a steam-pipe or a wire conveying an electric current, one may, even while using a poor thermal conductor for his lagging material, produce a cooling effect. A platinum wire with glass beads fused on it here and there will, when heated white-hot by means of an electric current, remain perfectly black and relatively cool under the glass. If the lagging be made thicker and thicker, a critical value will finally be reached where no cooling will take place. In elementary physics, it will be impossible to differentiate the expression for the heating effect and find just when it changes sign; but it requires only a moment to demonstrate the fact, to arouse the student's curiosity and to give him the proper impression, viz., that the lagging of a steam-pipe is a question well worth looking into. Here it will be seen that a part of the research, but not all of it, can be employed in elementary physics.

The same can be said of some of the properties of radioactive substances. Every student should see radium break down the insulation of air.

On the other hand, there are certain things one can safely avoid. I would mention, as examples of such, the quantum hypothesis in its present state, the relativity theory in its present state, all gravitational theories in their present state, and most atomic models in their present state.

To present physics in this manner will demand all the good judgment, all the knowledge, all the energy, and all the courage one can summon. In the midst of our abundant riches—our embarrassment of riches—in physics, I want to leave with you two words of advice, which I once received from a surgeon in Italy—a doctor who was mending an injured shoulder. My right arm was hanging limp and helpless at my side. I never expected to play another game of golf as long as I lived. His parting words

were "Adagio! Coraggio!" When memory fails me one of the last scenes I shall ever forget will be this white haired surgeon of Turin firing at me this volley of rich vowels saying, "Go slow, but never lose your courage!" These two words I have found useful in every walk of life. I trust you may find them so in the teaching of elementary physics.

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## CHEMISTRY ADAPTED TO SOCIAL NEEDS.[1]

By C. M. Wirick.

*Crane Junior College, Chicago, Ill.*

It isn't, if we consider the usual significance of "social" and "needs." With chemistry taught in second, third, or fourth years of the high school, before physics, along with physics, or after physics, there is no chance of supplying social needs. Pupils have learned to study books but are not able to study phenomena: and we, as teachers, are underpaid and overworked. We lack facilities in laboratory equipment and supplies, so some of us do not teach well. We follow a textbook till we get into such a rut that we can't see out of it, or do as one Chicago teacher has done this year—dictate question and answer for the student to memorize.

In the universe there are:

1. Some things we know and know that we know them. We know that we exist and think; we know food and drink, sunrise and sunset, heat and cold, plants and animals, earth and sky, cloud and water.

2. There are many things we assume to know but do not know. We assume that there was a man named Moses who led the Children of Israel out of Egypt. That another man named Columbus sailed westward over unknown seas and discovered a new world. We even assume to know our own ages and make oath now and then that we were born on a certain day of a certain month in a certain year; yet not one of us knows this of his own knowledge. We assume that the earth is round, yet not one in a thousand knows it of his own personal knowledge. We act on our assumed knowledge, and in many ways the results are satisfactory. Most of our history and science belongs to this second class.

3. There are many things we believe but cannot know. For example, belief in a Deity, in one, or three in one, or in many, or in none. This class need not concern us here.

4. Things we do not know and know that we do not know

[1]Read before the chemistry section, C. A. S. & M. T., Englewood High School, Nov. 1920.

them: The beginnings of space and time, if they had a beginning, and their ending, if they ever end. The creation of matter and energy, if they had a creation and their ending, if they ever end. Possibly it is not safe to speak of space and time since the days of Einstein but as he must postulate space, time, matter and energy in order to even state his theory, we may perhaps be allowed to think of them.

Now our business as teachers is to use every possible device to take items from the second class and perhaps some of the third class and put them into the first class for our students; to train the senses, and through them the brain, so that they know and know that they know—and chemistry is admirably adapted for such work.

The teaching of mathematics is undergoing fundamental changes. Students are to be taught each year, what they seem to need most and with no thought as to whether they are to go further or not—the idea being that what is best for them if they go no further will at the same time and for that very reason be best for them if they remain in school. Unified mathematics is already in the schools here and there. If our general science can be worked out in a similar way—and there are several first-year books to be had now—then our opportunity to adapt chemistry to social needs, that is, to the needs of each person in society, is such as no one before our time has had. A committee was appointed at the last high school conference at Urbana to report on the feasibility and advisability of carrying on in the sciences some such work as the mathematics teachers are doing.

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## SAVING WASTE FOR FUEL.

"Old rags, old bots" is a familiar call where the itinerant dealer in "junk" or the tin peddler makes his rounds, and those who have dealt with him know that he buys also discarded or waste metal and rubber. His was one of the first industries in the United States that made a business of saving "waste material." Among later similar industries is one that utilizes waste coal and waste petroleum residue in making fuel briquets. During the last ten years two and three-quarter million tons of fuel briquets have been made in the United States and sold for more than $14,000,000. The principal raw materials used in this industry are culm from the anthracite mines of Pennsylvania, slack produced by the rehandling of coal shipped by vessel to the head of Lake Superior, and carbon residue from the manufacture of oil gas. In 1919 twelve briquetting plants were in operation in the United States—five in the Eastern States, four in the Central States, and three on the Pacific coast. The output of these plants in 1919, according to the United States Geological Survey, Department of the Interior, was 295,734 short tons, valued at $2,301,054. *U. S. Geol. Survey.*

## THE TEACHING OF GRAPHS.

By Jos. A. Nyberg,
*Hyde Park High School, Chicago.*

With every plan for a reorganization of high school mathematics the subject of graphs and the ideas associated with it are made more and more prominent. There are innumerable ways of introducing graphs, and the present paper explains a method which the writer has used with good success.

Nearly all the text books begin the chapter on graphs by an illustration or two, followed by questions showing the usefulness of the graph as a pictorial representation of data or statistics. After doing this, they begin at once the study of plotting points, using $x$ and $y$ axes, coordinates, etc. This seems to be a poor method, for the pupil should have more illustrations and should himself make some graphs before beginning the study of the abstract notions which we know to be the common elements underlying all graphs. Realizing this, some books precede the study of coordinates by exercises showing, by the lengths of various lines, the comparative lengths of rivers or the comparative sizes by population of cities, etc. As a preliminary to graphing, the value of these exercises is also open to criticism. After such an exercise we have taught the pupil merely that a correct picture for a river 3,000 miles long must be twice as long as for a river 1,500 miles long; and if the pupil makes his own drawings, we teach him how long a line on paper must be to represent a population of 20,000 if an eighth of an inch represents 5,000. But that is merely a problem for the chapter on ratios and proportions, and is not a good introduction to graphs. If we are to teach more than the making of pictures, and believe with the National Committee that no pupil should be allowed to live through a year of algebra without being impressed with a realization of the existence of functions then some of our methods of teaching graphs must be revised so as to put the emphasis on the right spot.

We must distinguish for the pupil (1) the functional graph wherein the value of the ordinate depends on the value of the abscissa, whether or not we can state the dependence as an equation, and (2) the statistical graph where no such dependence exists.

In a previous article[1] the writer showed how the notion of

[1]School Science and Mathematics, December, 1920, page 831.

function can be started during the first or second month of algebra. Summarizing it here, the method begins when the pupil considers a problem like: Mr. Brown can allow his children all together a dollar and a half per week for spending money. In order to pay his carfare John needs 50 cents per week more than Elizabeth, while James requires only half as much as Elizabeth. What allowance will each child receive? If James' allowance is $x$, and the total distribution is $y$ instead of $1.50, then $y = 5x+50$; and the pupil prepares a table showing the total distribution when James gets various amounts. This table I have the pupils enter on some blank page in his textbook to make sure that it will be available for future reference.

A few weeks later the pupil may work such a problem as: The length of a rectangle is 6 more than twice the width. Find its dimensions if the perimeter is 72. When the problem has been finished I suggest that we call the perimeter $p$, write $p = 6\,w+12$; and again make and record in the text a table comparing the perimeters and the width. I also suggest calling the area A so that $A = 2w^2+6w$ and make a table showing how the area changes when the width is changed. A month later the class may have reached the problem: Two automobiles travel in opposite directions, the first going 20 miles per hour, the second starting two hours later and going 25 miles per hour. How many hours after the second started will they be 265 miles apart? Again, after finishing the problem, I suggest we call the distance apart $d$ so that $d = 45t+40$ and make a table showing the value of $d$ for any $t$. About this time I expect some youngster to ask while recording his latest table in the book, "What are we going to use these for?" If no one does ask such a question I assign every day one problem like the ones above until out of sheer disgust some impatient pupil *will* demand to be shown a use for his tables. Not till then do I begin the graph; and I prefer to begin with the problem about the rectangle.

On a horizontal line I mark points labeling them not 1, 2, 3, . . . but $w = 1$, $w = 2$, $w = 3$, . . . At the point $w = 1$ I draw a vertical line whose length is exactly 18 inches, that being the value of $p$ when $w = 1$. At $w = 2$ draw a line 24 inches long. Soon the blackboard isn't high enough, and after some discussion with the class we conclude that I had better shorten every line by making it a half or a third as long; and in order to remember what length it ought to be, I write $p = 18$, $p = 24$, . . . . along each line. The reader will notice that

ratios and proportions come into use at once; and since each pupil at his desk is doing the same work that I am doing at the blackboard but on a still smaller scale we must stop to discuss scales, units, etc. Next I ask: What improvements can be made in the looks of the picture? We decide to erase the numerous "$w =$ " and write $w$ just once, and write this at one end of the horizontal line; and then we discuss how the "$p =$ " can be eliminated. This introduces a single vertical axis with numbers on it, through which we draw lighter horizontal lines so that we can more easily read the values of $p$.

This discussion with the class about the appearance of the picture, a mere stage trick to be sure, I regard with very great importance. It differentiates two elements:[2] first, what are the essentials to make in the graph and, second, what are the non-essentials introduced to make the reading easier? In a printed book the words are the essential elements; the size of the type, the width of the margin, and the numbers on the pages make for ease in reading. Similarly, in a graph there are present certain essential ideas of correspondence, and certain other things introduced to make the correspondence easier to see, such as drawing a curve through the tops of the ordinates. After the pupil has seen why we have axes and curves, we can show him that when a graph is to be made from a table we draw first the axes, select our units and mark them on the axes, and then plot points instead of drawing ordinates. The drawing of the curve on ruled paper eliminates the necessity of drawing ordinates in the same way as the axes eliminated the writing of "$p =$ " and "$w =$ " at each point.

The amount of graphical work done at this stage may vary with the ability of the class. The previous problems for which tables have been made should be assigned, one for each of the following days, and the subject may then be dropped until the proper chapter in the book is reached. Or we may turn to that chapter and study graphs until we have covered the principal items of that subject. In such a case I return again to the rectangle problem, and graph on the same set of axes as before, the curves for both the area A and the length ($l = 2w+6$). This enables us to discuss such questions as: which increases fastest, the length, perimeter, or area? If a graph is a line we work out a numerical value for the rate of increase, stating,

[2]On this point see the writer's paper on "The Presentation of the Notion of Function," in *The American Mathematical Monthly*, September, 1917, page 310.

for example, that the length increases twice as fast as the width. This plotting of two or more curves on the same set of axes furnishes more material for discussion and a better chance to compare different kinds of variation. Problems on perimeters and areas of geometrical figures are numerous and useful.

The next problems are such as involve distance and time, or circumference and radii, Centigrade and Fahrenheit, emphasizing that there are three stages in every problem: (1) an equation between two quantities, (2) a table of corresponding values computed from the equation, and (3) a graph made from the table of values.

Under ideal conditions the class ought now to be taken into a physical laboratory in order to obtain by itself a table of corresponding values from an experiment instead of from an equation. A simple experiment would be that of measuring the elongation of a wire spring when various weights are attached at one end. This can be easily done in the classroom as the necessary apparatus is simple and the physical concepts involved are few. At the Hyde Park High School Mr. Kinney in the classroom performs the experiment of counting the number of swings per minute of pendulums (a ball at the end of a string) of varying length, obtaining a graph showing the relation between the period and the length. Such work not only furnishes material for a table of values, but also permits a discussion of various kinds of dependence. A good problem (though difficult to perform in a mathematics class) is that of plotting on one set of axes the graphs comparing the distance a body will fall in a given time and the velocity it will acquire in that time. In all this work the teacher ought to take advantage of the opportunity to talk about the dependence of one quantity on another. The use of the word function is neither necessary nor advisable. There should be as few new words as possible so that the pupil's attention will not be lost and emphasis be given to the idea that the pupil is not dealing with any new subject but is merely having his attention focused on something which he has always been surrounded by but never given thought to, just as he may have walked past a certain tree every day but never known whether it was a maple or an oak.

As a last step (not as a *first* step) in the study of graphs we consider those plotted from statistical data where no relation exists, curves showing the change in temperature during the day, or the size of some crop year by year, imports, exports,

commodity prices, etc. But in this work attention should be called to the fact that there may be no relation, either actual or undiscovered, between the numbers associated in the plotting. The size of the wheat crop does not depend on whether the year is numbered 1919 or 1920. However, there is one useful element of such graphs to which the books do not call sufficient attention. If, for example, we plot for the various years the size of some staple crop, and on the same axes plot the average price of the crop, then we can detect a dependence between the price and the size. In more general words, while $y$ may vary but not depend on the year, and $z$ similarly may vary but not depend on the year, we may discover a relation between $y$ and $z$ when both are plotted against the same units on the $x$ axis. This particular use of a graph is more important than learning "from the graph we can tell when the temperature was highest." It is the principal use that an economist has for a graph.[3] And if we believe in talking about the different kinds of dependence as illustrated in the problems from physics then we may well include at this point a discussion of: What do sizes of crops depend on? How do exports vary? etc. Plotting several curves on one set of axes increases the pupils' interest so much that I have almost entirely discontinued the practise of plotting only a single curve. We can discuss such vital questions as: Which goes up first, commodity prices or wages? Which changes more quickly?

Under ideal conditions again, the civics, history, and commercial geography classes would use a little more mathematics; and all the work of proving mathematics a useful subject would not rest with the teacher of mathematics alone. These classes are usually supplied with maps of Asia Minor, the East Indies, and Hendrik Hudson's exploration trips. They ought also to be ready to unroll at the psychological moment in the class a chart showing imports, comparative lengths of rivers, percentages of native whites and foreign-born in various cities, etc. But because some pupils do not stay in high school long enough to reach some of the junior and senior subjects, we are told we ought to crowd into the first year what amounts to a complete symposium of all the accumulated knowledge of the human race. And if we do yield to such popular advice, then immediately the advanced classes will prove to us how easily they can get along without mathematics.[4]

[3]See the publications of the Harvard Economic Service.

The above arrangement does not include the solution by graphs of linear simultaneous equations or the ordinary time, rate and distance problems, it being assumed that they will be solved by the usual algebraic methods. Such problems have been sacrificed in the above plan for a more thorough study of the notions of dependence. The value of such a sacrifice is always open to question. A graphical solution is, of course, interesting but a subject must be more than merely interesting to retain its place in the course, as witness the many problems which have disappeared from our algebras in the last decade. The writer feels that the prominence of graphical solutions is due to the fact that they are easy to teach and easy to learn; many a pupil who has no aptitude for mathematics can mechanically plot points. As a drill in graphical work they are easier but also less stimulating and less enlightening than the work suggested. Or, we may put the argument in another way: if the pupil continues in mathematics, the solution by graphing will be learned in the advanced courses where quadratics and cubics are considered; and if the pupil takes only one year of general mathematics, then the solution of simultaneous equations by graphs is of less importance than the notion of dependence, of the variety of kinds of dependence, and of comparative rates of increase.

*See "The Mathematics of Elementary Physics," P. F. Hammond, SCHOOL SCIENCE AND MATHEMATICS, November, 1920.

## ALASKAN SURVEYS IN ARREARS.

Last year's work by the United States Geological Survey, Department of the Interior, in Alaska, included geologic surveys of 2,700 square miles, topographic surveys of 2,300 square miles, and a continuation of stream-gaging work in southeastern Alaska in cooperation with the Forest Service, with special reference to the possible use of water power. This last-named work should be of benefit not only to mining but to the wood pulp and other industries. Owing to the decrease of the Geological Survey's appropriation for work in Alaska during the war from $100,000 to $75,000 and to the large increase in costs, the field work done since 1918 has amounted to only about 50 per cent of that done in preceding years, according to the annual report of the Director of the Geological Survey, just made public. Investigations in Alaska are therefore much in arrears, at a time when the large expenditures for Government railroad construction demand that every effort should be made to encourage the mining industry through surveys and investigations that will increase the knowledge of the distribution and occurrence of the mineral resources of the Territory. In the work done special emphasis has been placed on the surveys of regions tributary to the Government railroad, but it may also be pointed out that all advances in mining in any part of the Territory will directly or indirectly benefit and be benefited by the railroad.

# TESTS OF MATHEMATICAL ABILITY AND THEIR PROGNOSTIC VALUES. A DISCUSSION OF THE ROGERS TESTS.[1]

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As its title indicates, this paper is to be devoted to a review of Dr. Agnes L. Rogers' monograph *Tests of Mathematical Ability and Their Prognostic Value.*[2] High school mathematics, particularly first year algebra, has probably received more attention from the testing movement than any other high school subject. Many of these mathematics tests have received wide publicity through the various school journals and through the addresses of educators, and are, therefore, quite well known to the majority of progressive mathematics teachers. The Rogers tests, on the other hand, seem to be practically unknown to many members of our profession, possibly because in the only exposition of them which is so far available, there is involved a considerable amount of technical statistical method, which, although indispensable to the work at hand, may have proved to be rather forbidding reading for the busy teacher. These tests are, however, so different in most respects from those with which we have had the greatest opportunity to become familiar, that it seems well worth while to devote a little time to an examination of them here.

It will be helpful to make a brief comparison between the Rogers tests and some of the other tests of mathematical ability previously designed. The Rogers tests are intended to measure innate ability rather than the results of training. On the other hand, the Rugg-Clark Tests in algebra, with which all members of this conference are probably familiar, deal with the specific materials of classroom instruction, and hence serve as measures of teaching efficiency; indeed, it was the express aim of their designers that they should measure the progress which a given student or class is making in algebra. Of course, tests like these measure innate abilities also, since progress is necessarily dependent upon the natural endowments of the student, but it is clear that the environmental factor of class-room instruction affects the scores of these tests to such an extent that they leave much to be desired as measures of native intelligence. Continued drill or painstaking elucidation on the part of the instructor may have made the material of the test so familiar

[1]Presented at the Mathematics Section of the University of Illinois High School Conference, November 19, 1920.

[2]Teachers' College, Columbia University, Contributions to Education, No. 89.

to the student that a successful response can give no indication of his ability to think himself through a mathematical situation of a novel character—an ability most essential to all advanced work in this field. The same limitations hold for all other tests of first year algebra. Such tests, usually called tests of achievement, have, as has already been pointed out, a useful purpose to serve, but we need also something which will give us an accurate estimate of the capacity of the raw material with which the teacher has to work.

Most of the mathematics tests which have been published during the last few years are concerned almost exclusively with the mechanical or formal side of the work. It is on this account that they are strongly opposed by many professional mathematicians who charge that there is very little in common between the habits of symbol manipulation which the tester is emphasizing and those processes which characterize higher mathematical work. Another feature of the familiar tests is that they deal intensively with one particular department of mathematics. Thus we have, for example, the Courtis tests in arithmetic, the Rugg-Clark tests in first year algebra, and the Minnick tests in geometry. Now the engineer and the scientist do not apply the different parts of mathematics in isolation. Arithmetic, algebra, and geometry, in all their phases, may enter into the solution of one and the same problem. We require, then, a combination of tests which may be applied early in the Freshman year, and which will predict with reasonable accuracy the performance of the student in all his mathematics throughout the high school course. For this it would seem that something broader and more comprehensive than the special tests referred to above will be required. Tests which deal with the thought side of algebra must supplement those which deal with symbol manipulation; tests in geometry must include spatial intuition as well as the ability to make logical inferences; and any other activities which seem essential to mathematical thinking must be tested. Certainly an attempt must be made to include in the tests material which will typify some of the processes most fundamental in higher mathematics.

The value of such a group of tests must be obvious. Into every class room in high school mathematics, and especially into the required first year courses where slection and elimination have not yet had a chance to come into play, there come students whose abilities cover the widest range. In most cases

there is the group, more or less small, of those who are foredoomed to failure; in every high school with mathematics courses at all exacting, there are at least a few unfortunates who have been repeating algebra or geometry two or more times and who can never hope to become efficient enough in these branches to make the expenditure of time and effort worth while either to themselves or to society. Above this group we find another somewhat larger one, still inferior in ability, but not hopeless. Beyond this, there is a middle group, by far the largest in point of numbers, whose work is usually characterized as "medium" or "fair." Next to this group are the students of more than average ability whose number steadily decreases as their ability increases. At the upper end of the scale we find a very few students who are so gifted that they can achieve success in spite of the poorest class room instruction and the most poorly written texts. It is very desirable, surely, to have at our disposal some means of determining scientifically, and at an early stage in the student's career, his innate capacity to respond to mathematical instruction. With such a means at hand we can excuse from further instruction the more hopeless ones, and can make a better adjustment of our instruction to the varying needs of the rest.

Before such tests can be designed an analysis of mathematical intelligence must be made. Modern psychology tells us that general intelligence is a highly complex affair, a multi-dimensional structure, in fact, with a different measuring rod required for each dimension. There is every reason to suspect that the more special mathematical intelligence is complex also; for has not Poincare pointed out that there are the analysts and the geometers, the intuitionalists and the logicians, and that the activities of each of these are indispensable to the complete product which we know as mathematics? Mathematical activity must be analysed experimentally, then, into its components. Miss Rogers found it desirable to test as many different functions as possible which seem to be involved in high school mathematics, and then to discover in what way and to what extent these functions are related to one another and just how prominent is the contribution each makes to the complex which we call mathematical intelligence. After such an analysis has been made, the problem of selecting a group of tests, economical as to time and easy of application, and which will make possible the prognosis of mathematical ability, can profitably be undertaken.

The procedure in making the analysis was, on the basis of introspection, to compose an extended series of tests in accordance with the requirements outlined above, and then to apply these to typical groups of high school students. The results could then be analyzed by standard statistical methods.

With regard to the tests employed, we quote Miss Rogers' thesis.[3] "The tests used in this study were selected or devised to touch as many forms of mathematical achievement as possible in the particular groups examined. They can be divided into three chief classes. Six are tests of algebraic abilities and with these may be grouped a test of skill in problems in arithmetic and a test of ability to reason in symbols. The latter involves the selection of relevant data in order to deduce the required conclusion and is thus akin to the type of reasoning which predominates in algebra. The second class consists of five tests of geometrical abilities, three of which measure intuitive grasp of spatial relations, one the ability to infer with spatial data, and one the ability to generalize from spatial facts.

"Several of the tests, it will be seen, resemble ordinary classroom exercises, save that they are arranged in an order of increasing difficulty and were applied under controlled conditions. The other mathematical tests were designed to measure abilities which obviously play a part in higher mathematics or which previous psychological investigators have stated to be essential factors in mathematical ability.

"In the case of each new test prolonged preliminary trials were made and as a result some of the tests were discarded as unreliable or impracticable. Those were retained which gave the clearest indication of being adequate measures of abilities important in the mental equipment of the student of mathematics. Eventually the following tests were adopted:

1. Algebraic Computation
2. Matching Equations and Problems
3. Matching *N*th Terms and Series
4. Interpolation
5. Missing Steps in Series
6. Inference with Symbols
7. Geometry
8. Superposition
9. Symmetry
10. Matching Solids and Surfaces
11. Geometrical Definitions
12. Arithmetic Problems
13. Reasoning

"In addition to these tests of mathematical acivities a third series of tests of language ability was given. The purpose underlying their application was to discover how far weakness in mathematics depends upon or is connected with inferiority

[3]Pp. 16-17.

in command of the vernacular. The tests of language ability used were the following:

1. Mixed Relations
2. Logical Opposites
3. Trabue Language Scales
4. Thorndike Reading Tests"

To give some conception of the scope of the different tests a condensed description of the majority of them is given here. For the tests themselves in all detail, and a description of the method of administering them, reference may be made to their author's monograph.

*Algebraic Computation Test.*—This test consists of a set of exercises typical of all courses in first year algebra. Exercises from the earlier part of such courses predominate. There is included work in the evaluation of algebraic expressions, collecting terms, simple equations, removal of parentheses, and also a few very simple problems requiring translation of sentences into algebra.

*Matching Equations and Problems Test.*—This test consists of a series of verbal problems of the various types found in the earlier part of the first year work, and below them in a different order the series of algebraic equations which would be formed in the solution of these problems. The student is to match each equation with its corresponding verbal problem. This test requires no algebraic manipulation, and therefore measures the ability to translate verbal statements into symbolism as an isolated process.

Incidentally it may be remarked that of all the tests employed, these two are the ones which will be most affected by classroom training, and hence are open to the criticism that they do not isolate the innate abilities which it is the main purpose of the series of tests to disclose. The difficulties in the way of preparing such an ideal test of algebraic computation or of the ability to translate into algebraic symbols must be obvious; for such a test would probably have to be applied before the student had received training in algebra. The above tests are quite certain to meet the practical requirements of diagnosis.

*Matching Nth Terms and Series Test.*—In this test we have given a number of different series of integers, each series being derived by letting the letter in some simple algebraic expression run through the positive integers in counting order. Thus the series, 3, 7, 11, 15, 19, 23 . . . is generated by the formula $4n-1$ when $n=$ 1, 2, 3, 4, 5, 6. . . . The generating formulae of these different series are given on the same sheet

but in a different order. The student is to match each series with its generating formula.

*Interpolation Test.*—This test is composed of a series of arithmetic progressions with certain terms missing which the student must supply. The number of terms which must be supplied in a given series increases as we pass down the list. To make the nature of the test clear the first, eighth, and twelfth series of the set are given.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 5 | 7 | — | 11 | 13 | 17 | — | 21 | | |
| 2 | — | 8 | — | 14 | — | 20 | — | 26 | — | 32 | |
| 4 | — | — | 13 | — | — | 22 | — | — | — | 34 | |

In the actual test there is only a very slight increase in difficulty of each test over the one preceding it; so that by the time the second and third examples previously mentioned are met the student is in a position to infer the missing terms much more easily than would appear when these examples stand by themselves.

*Missing Steps in Series Test.*—This test is similar to that just described except that all of the four fundamental arithmetical operations are used in building up the different series.

*Inference with Symbols Test.*—This test aims to determine the degree to which mathematical ability depends upon skill in thinking in terms of symbols. The following first three exercises are typical:

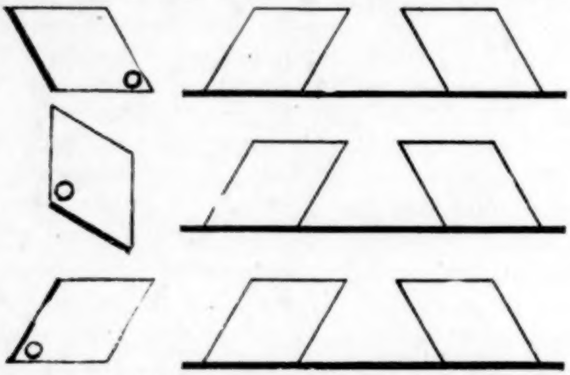
| Given Facts | | Fill In |
|---|---|---|
| 1. $a = b = c$ | Therefore | $a \quad c$ |
| 2. $a = b > c$ | therefore | $a \quad c$ |
| 3. $a < b = c$ | therefore | $a \quad c$ |

We pass now to a brief description of the various tests of the geometrical group.

*Geometry Test.*—The purpose of this test is to determine the ability of the student to deduce geometric truths with the aid of certain given geometric principles. It will be remembered that the students for whom these tests are principally intended have not yet studied demonstrative geometry. The principles given for reference are certain elementary theorems, among them the one on the angle sum of the triangle, those on the congruence of triangles, and the one on the equality of the angles opposite the equal sides of an isosceles triangle. Using these as working facts, the student is to solve a series of exercises, each of which consists of a lettered diagram concerning which certain information is given. On the basis of this information certain results are required to be proved with the aid of the principles given for reference.

*Superposition Test.*—This test is intended to discover intuitive geometrical power. "It consists essentially of pairs of symmet-

rical parallelograms, each with one side on the same straight, long, black line and each adjoining a third parallelogram of corresponding design, and similarly with one black edge, but such that it can be superposed upon only one of the adjoining parallelograms. This third parallelogram which has a small circle in one corner is placed in a variety of positions relative



to the pair of parallelograms. The task, in this case, was to imagine the third parallelogram moved around so that it fitted one of the corresponding pair of parallelograms, and to indicate which it was, by drawing a small circle in the corner of the same, exactly where the circle in the third parallelogram would then lie."[4]

*Symmetry Test.*—This is similar to the test just described except that the third parallelogram must now be turned over before being superposed upon one of the other two.

The two remaining geometrical tests, the *Matching Solids and Surfaces Test* and the *Geometrical Definitions Test*, will not be described in detail here. Suffice it to say that the first is intended to determine the student's intuitive grasp of tri-dimensional relations and the other is to test his ability to generalize on the basis of geometric material.

Two other tests of mathematical ability were employed. One of them was a *Reasoning Test.* The following exercise is typical:

| Given Facts | Fill In |
|---|---|
| M is younger than N | |
| K is older than N | therefore K is..........L |
| M is older than L | therefore N is..........L |

The other was a *Graded Problems in Arithmetic Test.*

Of the four different tests of verbal ability only two need be mentioned here. *The Trabue Language Scales* consist of a

[4]P. 31. All references are to pages in the monograph under review.

series of sentences with certain words omitted which the subject must fill in. The *Mixed Relations Test* requires the student to supply a fourth term standing in certain relation to three given terms. For example:

eye—see ear—
Monday—Tuesday April—

To discover the properties of all these different tests they were applied (1) to 53 girls in the Wadleigh High School, New York City, who had had five months of algebra but no geometry, and (2) to 61 pupils in the Horace Mann High School for Girls who had had five months of intuitional geometry and five months of formal algebra. The results were then scored by a carefully planned, objective, scoring scheme.

The data thus obtained was then analysed by statistical methods. The Pearson "Product-Moments method" of correlation was employed.[5] The main points concerning this method may be outlined in a few words. The aim is to measure the extent to which two traits measured in a group of individuals are correlated one with the other. Assume, for example, that a class has two sets of grades, one in algebra and one in geometry. Is there any tendency of a student's grades in these two subjects to be so related that, given one, we can estimate the other? Do high or low grades in the one subject tend to be associated with correspondingly high or low grades in the other; or is the relation of the opposite character, so that a certain degree of success in the one tends to be associated with a corresponding degree of failure in the other? Such questions are answered in an exact, objective manner by the Pearson coefficient of correlation $r$. In a word, this number $r$, calculable from a suitable formula, is an indicator or measure of the extent to which one trait measured in a group of individuals *tends to become a linear function* of some other trait measured in the same group. The number $r$ always lies between $+1$ and $-1$. If it is zero or very small, there is no evidence of such a linear relationship. If, however, $r$ were positive and of considerable size—if, for example, it were .40 or .50 in the case of our algebra and geometry grades, we would know that they were connected, so that high grades in the one tend decidedly to go with high grades in the other. The nearer $r$ is to one, the closer is the connection. In-

[5]For a brief but clear exposition of the leading properties of $r$ see Professor Huntington's article in the *American Mathematical Monthly* for December, 1919. This article lacks numerical illustrations but these may be found in any book on statistics.

deed, if $r=1$, which is the ideal case never realized in statistical practice, the correlation would be perfect; in this case if each pair of algebra and geometry grades was plotted as a point in the coördinate plane, the entire set of points would lie on a straight line of positive slope, and we could predict exactly a student's grade in geometry from his grade in algebra. When the points representing pairs of grades are more or less scattered throughout the plane, as is always the case in practice, $r$ measures the tendency of these points to concentrate about such a line. A corresponding set of remarks hold when $r$ lies between 0 and $-1$ except that in this case the two variates are so related that the larger the one is, the smaller the other which is associated with it tends to be. The method just described is one of recognized merit, and was used in the study of physical traits long before it came to be applied in psychology.

Using this method Miss Rogers calculated the coefficient of correlation between each of the set of seventeen tests mentioned above and every other test of the set. The large majority of the tests gave significantly high positive correlations with the most of the other tests. This means that the mental processes brought into play by the various tests are so related that efficiency in one of them means efficiency in the other also. In most cases tests from the same group are more closely connected with each other than they are with those of another group. The bonds connecting the different activities entering into algebraic ability are more intimate than the bonds between an activity of the algebraic group and one of the geometric group. Similarly, the tests of the geometric group gave scores which correlated more closely with each other than with the scores of the tests of algebraic ability.

Ten of the coefficients of correlation between the different mathematical functions exceed .50[6]. However, no function correlated perfectly with any other function.

The next step in Miss Rogers' work was to evaluate each of the above tests as a measure of mathematical ability. To do this, each test must be compared with some adequate and comprehensive standard of mathematical ability. Such a standard was obtained by combining all of the thirteen tests of mathematical ability described above into a single composite test. Since these tests taken together have a wider scope than any single test previously designed and since each of them does

[6] P. 64.

actually test some ability essential to mathematics, it would seem that such a composite would form the best available measure of general mathematical ability of the kind desired. To combine the scores of the individual tests so that they would have the proper weight in the composite was quite a complicated procedure which need not be gone into here.

It is possible to verify the accuracy of this composite as a measure of mathematical ability by comparing the results which were received when it was applied to a group of pupils with the records which these same pupils made in their school work in mathematics. This was done, and for the Horace Mann group there resulted a crude coefficient of correlation of .75.[7] This is an exceedingly high coefficient, and we see that from this point of view the composite is certainly an accurate criterion by which to judge mathematical ability.

The next step was to discover which tests showed the highest correlation with the composite. Tests which do this must obviously touch the most salient features of mathematical ability. In this way it will be possible to select a few of the above tests which are most indicative of the outstanding phases of mathematical thinking, and then to combine them into a single test, brief enough to be of practical use in the schoolroom for the prognosis of mathematical ability. We shall return to the consideration of this problem a little later on.

Without going into further detail as to method, we proceed to give some of the main conclusions to which this analysis of mathematical ability led.

Since it was found that no single test correlated perfectly with the composite, no one test can serve as an adequate measure of mathematical ability.

"Algebra and geometry depend on activities of different kinds." Indeed, the correlation between algebraic ability and geometric ability is no greater than that between algebraic ability and verbal ability or between geometric ability and verbal ability. The corrected coefficients of correlation were as follows:[8]

| | |
|---|---|
| Mathematical ability and verbal ability | .65 |
| Algebraic ability and verbal ability | .57 |
| Geometrical ability and verbal ability | .59 |
| Geometrical ability and algebraic ability | .54 |

Such data as this makes clear the important part which the mastery of language plays in secondary mathematics. The ability to get meanings from mathematical relations verbally

[7] P. 86.
[8] P. 80.

stated seems fully as important as the ability to manipulate symbols. It is through the ability to comprehend verbal expressions of mathematical facts that the student makes his entrance into the symbolic part of mathematics.

The results we have just stated confirm the conclusions of earlier investigations based on school marks and examination papers. Again, in a recent investigation of grades obtained from several representative high schools (as yet unpublished) Professor Crathorne of the University of Illinois found that algebra and geometry were no more highly correlated with each other than each is with German. Such findings as these hardly lend support to those who contend that algebra and geometry should be woven together into a single course in correlated mathematics.

By the method of partial correlation Miss Rogers was able to show that the correlation between algebraic ability and geometric ability *apart from the common element of verbal ability* was only about .33.[9]

We see, then, that the functions represented by the three groups of tests for algebraic, geometrical, and verbal abilities are to a large extent independent and each is essential in mathematical ability.

The following statements are from Miss Rogers' summary of the results of her analysis. "The results so far obtained lend further support to the view that mathematical intelligence is complex in character, embracing a variety of mental processes, which are somewhat loosely related, but equally indispensible for successful accomplishment in the subject. A more penetrating analysis of its general nature has still to be made." A little further on we find the statement that "while mathematical intelligence can neither be satisfactorily diagnosed, nor explained by reference to a single test or a single mental process, yet the experimental evidence we have obtained suggests that a marked degree of the power to analyze a complex and abstract situation and to sieze upon its implications is the most indispensable element in mathematical proficiency."[10] It is that selective faculty of the mind, "the capacity to react to partial elements in a situation," which Miss Rogers concludes is the common element operative in all the tests, and which is responsible for the positive correlations which exist between the large majority of them.

[9]P. 32.
[10]P. 85.

On the basis of the above analysis it was possible to proceed to the main object of the investigation, namely, the discovery of a small group of tests brief enough and convenient enough to be used in the high school for the diagnosis of mathematical ability. The problem is to make the best selection of such a group from those already described. You will remember that a while ago I explained how all of the thirteen tests of mathematical ability were combined into a single composite and that the score of each student in this composite was taken as the measure of that student's mathematical intelligence. For the diagnostic test it was then necessary to select from all tests tried those which were most prominent in influencing the score of the composite, the degree of influence being measured by the size of its coefficient of correlation with the composite. Furthermore, those tests must be chosen which show the lowest correlation with each other; for two tests which correlate highly with each other must test the same phase of mathematical activity, and hence would duplicate each other. Tests which are loosely correlated with each other, but highly correlated with the composite must each be indicators of distinct phases of mathematical ability. Largely on the basis of the aforementioned criteria, the following six tests were selected from the available seventeen.

1. Algebraic computation
2. Interpolation
3. Geometry
4. Superposition
5. Mixed relations
6. Trabue lagnuage scales

This sextet of tests is for practical use by teachers. These tests measure among other things "the ability to manipulate numerical and algebraic symbols, the ability to grasp and handle spatial relations, and the ability to deal effectively with words." They can be administered in an hour and a half's time, and are very easy to score.

For the purposes in view these tests have many advantages over the ordinary classroom test. Some of these advantages have already been pointed out, and a few others may now be mentioned. First, they have been shown by statistical methods to be reliable. This means that if they are applied two or more times to the same group of individuals, the two or more sets of scores obtained would agree closely with one another. Obviously tests for which this not the case can be of very little value. In the second place, the tests are objective. This means that

the different questions which make up each test have been so framed as to require a response recognizable as definitely right or wrong, and to this response there is attached a definite score. If the response consists of more than one step these requirements must hold for each step. If a student's replies to such tests are corrected by two different individuals, the total score obtained by each must be practically the same. Contrast with this the ordinary geometry paper which is graded according to subjective standards of the widest variability. Elliot and Starch found that one such paper received grades ranging all the way from twenty-five to eighty-eight when corrected by different teachers in a group of schools all having the same passing grade.

In the third place, the sextet of tests has a known high correlation with other tests of mathematical ability (as embodied in the composite of thirteen) and with classroom grades. The sextet has been found to give a correlation of from .60 to .80 with the results of classroom work.

Before these tests can be useful they must be standardized. They must be tried out with large representative groups of students, and from the results obtained norms must be established, so that it will be possible to compare the score of any particular student with the average results for a large number of others of the same age and training. When this standardization has been completed, a "dead line" can be established below which a student's score in these tests cannot fall if he is to be considered a fit subject for mathematical training. On the basis of these norms students may be grouped into classes according to their ability, and instruction varied in each class to meet its special needs. Possibly the tests will also be of use to the teacher in discovering latent power in a student whose real ability might not be apparent in his classroom work because some factor outside of school might be preventing him from making the proper application to his work.

If standardization is to be of service, tests must always be applied under uniform conditions, so as to make a comparison of results possible. The Rogers tests are accompanied by definite, detailed instructions as to the way they should be presented in the classroom.

## THE PROJECT AS A TEACHING UNIT IN HIGH SCHOOL PHYSICS.

By B. Clifford Hendricks,
*University of Nebraska, Lincoln.*

"Give my boy the principles of physics and he'll make the applications without any assistance from the teacher," was the remark of a very prominent physicist to the writer upon a certain occasion. On the other hand, another prominent teacher of this subject, as far back as 1912, in an N. E. A. meeting said, "A course in physics should deal largely with *real* things." Which is correct?

There are two ways of answering this question. Either by theory, that is by sitting down and reasoning out an answer, or by experimentally determining which is the more nearly correct so far as results are concerned.

To follow the first line of attack in the present case requires a study of the human mind, its unfolding, and its behavior when engaged in the learning process. This takes one into the study of youth, a study of that uncertain period; for it is at that time in the student's life that the subject of physics is taught. So, in giving attention to theory, the emphasis is changed from subject matter to subject recipient.

The latter of these methods sends us into the field with our educational litmus paper. "What is its reaction?" is our query. Have boys and girls, in general, made applications as the fundamentals were unfolded to them? Or does a procedure based upon applications give successful and lasting results?

It is the plan in this paper to deal with both of these methods. Some little attention will be given to the thinking processes and the demands of our modern social life, but a major part of it will consider: (1) the success of current methods of physics instruction, (2) a method which attempts to study applications at the outset, and (3) the results of this somewhat new departure in physics teaching.

The writer holds that thinking originates, always, in an attempt to unravel some difficulty or some mystery. That it begins with a problem, that it is accompanied by an emotional glow of changing intensity and that the time during which the attention is fixed upon any one problem varies with this emotional intensity. The difficulty must arise out of an easily interpreted situation so that some facts related to it are easily secured, that these facts are brought together and made a basis for a plan of action which when tested and found successful

helps toward the solution of the problem or when tested and found untentable is discarded for other plans, or hypotheses. He claims nothing original for this way of thinking, for Dr. John Dewey is its author.

The writer further considers that teaching is an attempt to make those taught a more dynamic part of the social world in which they are and from which they come. He considers that the subject matter must be drawn from the community life or be closely related to that life though not neglecting the subjects relating to the more general world community. He believes that a community that taxes itself for the support of an institution, the public school, should not have the opportunity to say that that school is taking the community's life from it to build up some other community. That some, at least, of the school's output should remain in the community to enrich its future life. This means, in his opinion, that the pupils in the school should ever be regarded as social beings. That the teaching process should recognize this by socializing its methods; by seeing to it that even the formal classroom work gives opportunity for the give and take between pupil and pupil, as well as between pupil and teacher.

The writer feels that much of our science instruction could come as contributory to the successful carrying forward of some project. This method will carry its own problems, it has the emotional element, the felt need for the instruction; there are abundant hypotheses formed and tested, and finally the final result is tested out in a real-life situation. If this scheme of teaching is used and each student urged to work upon his or her own problems, these individual reports will put the student forward so that the class interplay will be between student and student rather than between teacher and student.

This doctrine sounds promising, in fact rather Utopian, perhaps. "But," some one may remark, "is it not well to leave well enough alone? Aren't we doing pretty well as it is?" In reply to this, most everyone is well acquainted with the galling misconceptions our students get in the formal presentation of physics. Misconceptions which may be largely credited to *word cramming,* where there should have been *idea gathering.*

While the boy's definition of velocity as "What a feller lets go when the hornets get after him" may be extreme, all have read papers from students that had attempts at definitions that were even more aside from the mark than this one.

Again when as many as 42 per cent of the students studying physics express themselves as disliking it, when we know that every one of them is going to have a large part of his or her life spent upon or in contact with machines; it is time that we begin to do some thinking. Perhaps there may be a remedy for this unfortunate condition of affairs.

From a report secured from 165 Nebraska high schools in 1914, 77 per cent of the 170 teachers reported that they were following a textbook very closely. Eight per cent were following the text very closely, even though they did not favor its method and five per cent introduced all topics by a textbook assignment. This would indicate that even in this day and age physics is being taught as a textbook subject. From the above, I would have you sense that we still have a physics teaching problem that is not yet solved and, that granted, it is not out of order to present a hypothesis which may be a step toward a cure for the dislike expressed, so generally, by our high school people.

In keeping with the thought already expressed, that the alert human mind naturally is working more or less constantly upon projects of its own propounding, the following is submitted as a working hypothesis of physics instruction: 1. That instead of making our division of subject matter hinge upon formal logical arrangement, that it develop from a series of community projects. 2. That specific, locally useful generalizations be given broad application through the uses of a generous assignment of exercises and questions for thought and reference. 3. That facts, principles, and related matter upon a topic be given a logical grouping at the close of the project by a summary outline. 4. That the practice in testing out these facts and principles be secured through the assignment of individual projects, either qualitative or quantitative in character, requiring work in the laboratory or, maybe, satisfied by an original first hand study of some physics problem in the home.

It has been found, for instance, that all topics ordinarily presented upon work and machines can be naturally evolved by a study of the project "How get water into our houses?" A little thought readily brings to mind the well bucket with its pulley; the old windlass type of well with its wheel and axle; the chain pump with its crank, gear, and reversed wheel and axle; the lift pump with its levers and the stairway as the inclined plane. The same theme can be continued in "How are towns and cities supplied with water for domestic use and fire prevention?"

with a view to teaching the essentials of fluid pressure. The pneumatic aspect of this topic readily comes from a consideration of the compressed air type of water pressure system.

Without going further into details, the formal topic of motion may come through a study of railway trains and their motions; force, their compositions and resolutions, by a study of braces and guy cables; fluid power, by a study of water lifts, found in many up-to-date houses; sound from the piano; heat from home heating devices and the steam engine; molecular physics from weather and its causes; electricity, from the door bell and the electric light; light from "illuminating our houses," and the camera.

Each project is begun in the field. By that is meant, for example, a trip is taken to the city pumping station, when fluid pressure is introduced. Each student has in his hands specific directions with definite requirements to report upon. Out of these field trips, it is expected, will come the problems which will carry forward the class and laboratory work upon the project. The most significant of these are used as "topic questions" for the experiments. "What is meant by 140 pounds per square inch of pressure?" or "Suppose the tower tank were filled with kerosene, how much would that change the pressure per square inch?" or again "How do bends in the water mains, or kinks in the fire hose, influence the distance water may be thrown in case of fire?" Thus by a series of four field studies and thirteen experiments all of which have to do with: ,How Peru people secure running water upon any floor of their houses," the essentials of the more abstract topic "fluid pressure" were presented. Interspersed with these studies and experiments, numerous exercises were used to give added meaning to principles which have just been developed.

After the project and its specific problems have been worked out, the next attempt is toward more complete generalization. This is done by organizing what is called a summary outline. This outline is a nearer approach to old idea of what is called logical. While the project as a teaching unit has made the stress center in the relation of principle to application, in this outline more attention is given to the relation between principle and principle. The project has constantly sought to interest, the outline attempts more in the way of classification. While the project has sought to be pedagogical, the outline seeks to impress the fact that science is classified knowledge.

In the use of the outline is found the chief occasion for using the text and other books of reference. The subject matter, in the study of the project, has come largely from observation and inference but in this, next to the last, step in this teaching process the appeal to books helps to crystallize into better English the definitions and principles previously worked out. By the aid of the outline, topical reports during the class conference may call forth the most natural type of socialized class work in which members of the class "come back," so to speak, at the one reporting. So used, it serves as a highly desirable antidote to the question and answer method so likely to prevail in the development work upon the project.

Here, too, is a step in the plan which will effectually allay the alarm of some good teacher who feels that the project presentation is going to make the student's knowledge of the more formal topic disorganized and piece-meal in character. Here, too, is the opportunity for class review, a review in the best sense of that word, for the facts already acquired are placed in new relations which give them, if not new meanings, at least added significance.

But the work upon the topic is not yet complete. There yet remains application in as nearly life situations as possible. This can be done in no better way than by actually doing something requiring such application. In regard to the value of such procedure one writer says, "If the problem does not seem to allow any application, we may well inquire whether the problem is worth while or not." The writer feels that one of the curses that comes with schooling as we give it today is the passive attitude which we teachers induce by surfeiting our students with stimuli to action which never find expression in any sort of response. "Passive assent" describes the situation. We, in our physics instruction, must not only get the principle stabled in its proper mental stall, but we must see that it is harnessed and broken to work as well. It is with this in mind that the following closing step in the study, any topic is advocated.

In the presentation of the topic through the project study, the student has, presumably, learned something of the manner of attacking a project problem. Consequently, he is not entirely ignorant of a method so likely to prevail in the development work upon the project.

These project problems may be of three types: laboratory problems, home research or interpretation problems, and con-

struction problems. The first, as the name indicates, is worked out principally in the laboratory. Such problems as: How may I find my weight when I have but one spring balance and it will measure but thirty pounds? or, How much heat are the different foods of my dinner capable of producing? or again, How do the candle, the kerosene lamp, and the electric incandescent lamp compare in cost and efficiency? are of the laboratory type. The second group of problems sends the student home to study and interpret some appliance or process. In this class may be mentioned: What kinds of simple machines are in our sewing machine and why are they there? How does the water meter measure water that goes through it? What is a fireless cooker made of and what can be done with it? and What is the proper relative humidity for living rooms and school rooms and how nearly do our rooms attain to those standards? Some construction projects are: How make and walk on stilts? How make a wind-mill and why does it run? and, How is the Little Hustler motor made and how does the current make it go?

In preparing upon these, each student, after selecting his or her problem, is expected to make out a scheme of attack. This plan is crystallized into a project study outline. From the outline, which may be modified as the study progresses, the study is made first-hand, especially upon the home projects. Experiment projects may require some library reading before a plan of procedure can be formulated. In this experimental work careful report is required upon: (1) what was done, (2) what was noted and (3) what was learned or meanings attached to results secured. Students are encouraged to embellish their reports by diagrams, sketches and snap shots. While they are strongly advised to begin work by a study of the real thing, making it answer their questions as fully as possible, there are no objections registered against securing help from other people or from books, in interpreting results. It is strongly stressed, always, that where information from other people or books is used, the proper credit should be given the source in every instance. The report upon the project, when completed, is presented in the form of a paper and is usually read, or a digest at least, given by its author.

The following, presented by Miss Helen Hopp, a member of one of the writer's classes, illustrates the application of this last step in the teaching round:

## Refrigerator, a Project Study Outline.

1. Introduction:
    1. Selection of project.
    2. Purpose of a refrigerator.
    3. Problem:
        1. How does a refrigerator accomplish the purpose for which it was designed?
2. Material used for walls:
    1. Why selected.
    2. Insulated:
        1. Material used for insulation.
        2. Purpose of insulation.
        3. Influence on efficiency of refrigerator.
    3. Lining:
        1. Material used for lining.
        2. Purpose of lining.
    4. Partitions:
        1. Where located.
3. Parts of a refrigerator:
    1. Ice compartment:
        1. Location.
        2. Why corrugated.
    2. Shelves:
        1. Removable.
        2. Made of wire.
    3. Drain pipe:
        1. Shape.
        2. Bell and trap:
            1. Purpose of.
4. Air circulation:
    1. How established:
        1. Ice.
        2. Gravity.
    2. Purpose:
        1. Effect upon cooling.
        2. Effect upon moisture.
        3. Effect upon odors.
5. Drainage:
    1. How established:
        1. Drip pan.
        2. Drain tube.
6. Conclusion:
    1. Refrigerator is aided in doing its work by:
        1. Material of which it is made.
        2. Parts.
        3. Circulation of air.
    2. Modern inventions by which the refrigerator may be replaced.

## The Refrigerator, a Project Study.

"It has always seemed to me that a refrigerator was a sort of apparatus which was used to keep food cool, so that it might be preserved a longer time, and would be better suited for table use. Before beginning this study, I had never thought of just how this is done. I had always known that ice is used in refrigerators and that it is the means of cooling the things within, but just how it accomplished this I had never thought to question. I shall take this then as the aim of my study: How does the refrigerator accomplish the purpose for which it is designed?

"The first thing that drew my attention was the material from which it is made. Those which I had seen having been made of wood, I concluded that this material was most commonly used. This seemed reasonable, as wood is known as a poor conductor of heat and would therefore keep the heat of the room from entering. Reading and investigation showed that the walls of all good refrigerators are insulated, that is, are made of a number of layers of wood between which is placed mineral wool, a poor conductor of heat. The walls are insulated because the amount of heat which enters the refrigerator depends upon the efficiency of the insulation. If the insulation were ideal, the ice would melt until the temperature of the air in the refrigerator was 32°F. The ice would then stop melting and the air would always be at 32°F. However, we cannot get perfect insulation and some heat always passes through the walls. The amount increases as the temperature of the room increases.

"In order to find the amount of heat that passes through the walls I put 49 lbs. of ice into the refrigerator at 6:35 a. m. By weighing the ice again at 12:35 p. m. I found that 6 lbs. of ice had been melted in six hours. It takes 144 B.t.u. of heat to melt one pound of ice. To melt 6 lbs. takes $6\times144$ B.t.u. = 864B.t.u. The temperature of the water when it left the refrigerator was 40°F. This means that it was heated from 32°F to 40°F or through 8°F. To heat 6 lbs. of water 8°F required 48 B.t.u. of heat. The total amount of heat that passed through the walls was 864 B.t.u. + 48 B.t.u. = 912 B.t.u. The temperature of the room while this test was being made was 70°F and that within the refrigerator was 40°F.

"Besides the wood and insulating material, I also found the refrigerator to have a lining of white enamel. Inquiry showed not heat but cleanliness to be responsible for this.

"I next made a study of the different parts of the refrigerator. It is divided into two parts by a solid perpendicular partition which has an opening running the entire width at top and bottom. The left side is divided by another partition and the upper part is used for the ice compartment. This is lined with galvanized steel. Since the food does not come in contact with this part, the enamel is not needed. The ice rests upon strips of galvanized steel. The reason for this puzzled me for a time but the dealer told me that it was to allow the water to drain off so that the ice would never be standing in water.

"There is one shelf below the ice chest and there are four

in the other part of the refrigerator. These shelves are made of wire. They are removable so as to prevent difficulty in cleaning.

"The drain pipe consists of two straight tubes and is also removable. At the end of the pipe is a bell shaped piece of metal, which keeps the air of the room from entering through the pipe.

"When the air in the refrigerator comes in contact with the ice, it causes the ice to melt and in melting the ice takes heat from the air. This air when cooled becomes denser than the other air and gravity pulls it to the bottom and pushes the less dense air up toward the ice. This air is then cooled and sinks. Thus a convection current is established.

"The wire shelves and the opening in the top and bottom of the partition permit a free circulation of the air. The ice is placed near the top so that the cold air can fall and establish this current. This air circulation cools the food because as the cold air sinks it takes heat from the food and also from the walls of the refrigerator. It also keeps the air very dry. The air takes moisture from the food but when it reaches it is cooled and this means that the moisture is condensed and left on the ice. All the odors from the different foods are also left on the ice. The circulation continues as long as the bottom and sides of the refrigerator are warmer than the ice. When the ice melts, the water runs down into a drip pan. The drip pan slants downward so that the water flows into a tube and then into some arrangement under the refrigerator. In the refrigerator which I took for my study, a pipe was connected to the tube and lead through the floor of the room to the basement, where the water entered a tank kept there for that purpose.

"Thus I find that the refrigerator accomplishes its purpose by the aid of the material from which it is made, its different parts, and the air circulation. I find that the most important factor influencing its construction is heat, but I find that cleanliness is also a very important factor, as it is a storage place for food.

"It is possible that the ice refrigerator will in time be replaced by the compression machine refrigerator. In such a machine ammonia or some other refrigerant is employed. The refrigerant acts as a heat carrier, taking up heat as it evaporates and discharging it into water. These machines are now frequently used in large factories but, as there are many difficult problems

to overcome in such a device, it is probable that for home use the ice refrigerator will be more popular for some time to come."

"In theory, good," some good teacher says, "but how about practice?" It was used for three years in the Peru Normal, and in the past five years has been in use in fifteen high schools of Nebraska and South Dakota and in the words of more than one user, "They bring the value of physics home to the pupils."

In the writer's own classes, two hopeful signs have been noted since beginning their use. First, an active initiative in asking questions of the guide in the field trips, an initiative not found in other methods of presentation. Almost without exception, a class in the presence of a hot water boiler, a hot air furnace, a water lift, in a pumping station or in the presence of other field material, in a very short time is fairly deluging the guide with questions. Second, time after time the very problems which are to be used in directing the laboratory experiments, growing out of the field work, have been raised by the students themselves without any coaching whatever from the instructor. Evidently the problems selected have been along the line of the pupils' interests. It is a course that anticipates their needs.

Another testimony that may be worth noting is that a more than usual per cent of the girls of the classes have not only evinced a growing interest in the work, while taking it to work off required credits, but have elected to continue the subject as an advanced course. The experience of high school teachers of physics will support the writer in saying that a large per cent of the girls not only do not get on well with this subject but positively dislike it.

The trend of the times is toward a study of pupils' interests with a view to instruction with less "beating of the air," with a greater efficiency upon teaching effort. A glance at our latest textbooks serves to impress this new trend upon our attention. Such titles as Civic Biology, Everyday Physics, Physics with Applications, Practical Physics, Physics of the Household, and many others that might be named, all testify to this movement of teaching practice.

## PROBLEM DEPARTMENT.

**Conducted by J. A. Nyberg.**

*Hyde Park High School, Chicago.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.*

656. Solved in the November copy. The *Proposer* calls attention to the fact that the line AD need not be outside of $\triangle$ABC, but may intersect the base BC, and if $\angle$DAB is greater than 90°, then $\angle$DAB is one third of the reflex $\angle$DAC, and that the only necessary restriction is that AD must not be perpendicular to BC. The *Editor* thinks that this is just the kind of a problem every teacher should have on hand to assign to the brighter pupils in the class who want to do a little "extra work" from time to time. Its many possible variations despite its apparent simplicity are the qualities that make it attractive. The problem in its general form would read as follows: If a line BD is drawn from a point B, in the common side of two angles BAE and BAC (either adjacent or overlapping), making an angle of 30° with AE and such that BD = BC, then $\angle$DAB is one third of $\angle$DAC.

670. A complete and altogether exact solution received from *Robert Gibson, student* at the *Senior High School, Adrian, Mich.*

## SOLUTION OF PROBLEMS.

671. *Proposed by Emma H. Carroll, Phila. High School for Girls.*

Without the use of trigonometric relations prove: the distance on a side of a triangle from a vertex to the point of tangency of the inscribed circle equals one-half the perimeter minus the side opposite the vertex.

*Solution by J. Pickett, Ranger, Texas.*

Let ABC be the given triangle, with the inscribed circle tangent to AB, BC, CA at D, E, F, respectively. Then AF = AD, BD = BE, and CE = CF since tangents from a point to a circle are equal; and

$$AD + BE + CF = s/2.$$

or $$AD = s/2 - (BE + CF) = s/2 - (BE + CE) = s/2 - BC.$$

*Also solved by W. D. Baten, Arlington, Texas; N. Barotz, New York City; Moe Buchman, senior at Boys' High School, Brooklyn; Thomas E. N. Eaton, Redlands, Calif.; Michael Goldberg, Philadelphia; E. J. Libby, Raymond Neal, students at the Tilden Technical H. S., Chicago; Lucille A. Mower, Bedford, Ind.; Hilda M. Mullen, senior at Lewis and Clark H. S., Spokane, Wash.; C. O. Pauly, Valparaiso H. S., Ind.; R. V. Pritchard, Rolla, Mo.; Will W. Ramsey, Perth Amboy, N. J.; M. G. Schucker, Pittsburgh, Pa.; Ila Smith, Forrest Young, students at Redlands H. S., Calif.; Julia Spaulding, Smead School, Toledo, Ohio; R. C. Staley, Eagle County H. S., Gypsum, Colo.; Frederick L. Sweeney, Mt. Holly H. S., New Jersey; M. D. Taylor, Scott H. S., Toledo, Ohio; T. F. Tyler, Supt. Schools, Valparaiso, Nebr.; The Advanced Algebra Class of F. C. Goodwin, Waynesville H. S., Illinois.*

I. The above exercise is used extensively as a link between geometry and trigonometry as many of the half-angle formulae can be derived from it. In the *American Mathematical Monthly*, September, 1920, *R. D. Bohannan* shows how these formulae are derived by using the inscribed and escribed circles of the triangle. A similar method is suggested by *C. M. Himel, Maine Township H. S., Des Plaines, Ill.* Multiplying the equation $\tan A/2 = r/(s-a)$ by $s$, and noting that $rs$ is the area of the triangle, we see that the area is $s(s-a)\tan A/2$; but the area is also $(bcs\ \mathrm{in}A)/2$. Equating these two expressions, we get a relation from which the various functions of the half-angle can be found.

II. It may be of interest to see how variously the problem was treated. Of the 22 solutions, 8 used letters $a, b, \cdots x, y, \cdots$ to denote the lengths of various lines. With the exception of 2, all used capital letters to denote points. Only 8 stated the theorem giving the reason why AF = AD, etc. Three solutions began essentially with AD = AB + BC + CA − (DB + BC + CA) and then proceeded to change the right member until the desired end was reached. Twelve made AF = AD etc., their first statements and then derived the results by additions, etc. Six did not say in the body of the proof that AF = AD but let the equalities be inferred by lettering the equal lines in the figure with the same letters, $x$, etc. One solution began with the relation to be proved and reduced it to an identity. Seven proved very carefully by proper use of axioms of addition, substitution, and division that half the perimeter was AD + BE + CF. The proofs by the 6 undergraduates were as unlike as 6 can be. All of which shows merely that however much alike our textbooks may be, the individual varies.

672. *Dissection Problem proposed by Norman Anning, Ann Arbor, Mich.*

An equilateral triangle AFG is described outward on the side AF of the regular hexagon ABCDEF. Cut the figure so formed into 3 parts that will make an equilateral triangle.

I. *Solution by Frederick L. Sweeney, Mt. Holly H. S., New Jersey.*

Join G to C, and C to the midpoint, H, of ED. Place △GBC so that GB lies on its equal line GE, and place △HDC so that HD lies on its equal line EH.

Proof: Draw GH. Let K be the third vertex of the triangle formed. Since GK = GC, and since ∠KGC = ∠KGE + ∠EGC = ∠BGC + ∠EGC = 60°, the △KGC is equilateral.

*Also solved by J. Pickett, R. V. Pritchard, M. G. Schucker, and the Proposer.*

The proof is not complete unless we show that the sum of the 3 angles at the point E, ∠GEK, ∠GEH, and ∠HEK is 360°, for otherwise we may have placed the parts together so as to form a five sided figure instead of a triangle. This difficulty in the proof is avoided in a solution by *F. A. Cadwell, St. Paul, Minn.*, by joining B to E and extending BE to K so that EK = CD, and then proving the various triangles congruent.

II. A dissection problem is not entirely a matter of guess work or experimentation. In the preceding problem, for example, we see that the area of ABCDEF is the sum of a hexagon $(2a^2\sqrt{3})$ and a triangle $(a^2\sqrt{3}/4)$, and this must equal $x^2\sqrt{3}/4$ where $x$ is the side of the desired triangle. Hence $x = a\sqrt{7}$, and our problem consists in finding a line of this length in the given figure. Are there any dissection problems which cannot be analyzed in this fashion? Would not a collection of them be useful for the chapter dealing with numerical work on areas of various figures? The department will be glad to collect and print any that the readers will send in.

673. *Selected.*

A father settled an annuity upon his three children, the same to be divided each year in the same proportion as their ages. At the first division, the oldest was entitled to one-half of the entire amount. When the sixth payment was due, Martha received one dollar less than she did the first year, Phoebe one seventh less than she first got, while John's share was twice as much as he received the first year. What is the amount of the annuity?

I. *Solution by Will W. Ramsey, Perth Amboy, N. J.*

Let $a$ = the annuity, and

| | Age at first payment | Share at first payment | Age at sixth payment | Share at sixth payment |
|---|---|---|---|---|
| Phoebe | $x$ | $\dfrac{xa}{x+y+z}$ | $x+5$ | $\dfrac{(x+5)a}{x+y+z+15}$ |

| | | | | |
|---|---|---|---|---|
| Martha | $y$ | $\dfrac{ya}{x+y+z}$ | $y+5$ | $\dfrac{(y+5)a}{x+y+z+15}$ |
| John | $z$ | $\dfrac{za}{x+y+z}$ | $z+5$ | $\dfrac{(z+5)a}{x+y+z+15}$ |

The equations are $x = y+z$

$$a(x+5)/(x+y+z+15) = 6ax/7(x+y+z)$$
$$a(y+5)/(x+y+z+15) = -1+ay/(x+y+z)$$
$$a(z+5)/(x+y+z+15) = 2az/(x+y+z)$$

Substituting $x$ for $y+z$ in the second and fourth gives $x = 10$, $z = 2$. Then from the first, $y = 8$; and finally $a = 35$.

II. The foregoing solution assumes $x = y+z$, as the problem does not state who is the oldest. The assumption $y = x+z$ leads to the result $y^2 = -75$; and the assumption $z = x+y$ leads to $z = -10$, $x = -70/11$. The correct assumption is derived analytically in a solution by *J. Pickett* as follows:

Comparing $(x+5)/(y+5)$ with $x/y$, and $(y+5)/(z+5)$ with $y/z$, wherein $x$ is the oldest and $z$ the youngest, we see that the ratio of the amount received by an older child to that received by a younger at the sixth payment is less than the same ratio for the first payment. Therefore, since two of the children receive less at the sixth than at the first, while one receives double, we can conclude that the youngest is the one whose share is doubled. Assuming that the second in age is the one who receives one dollar less at the sixth payment, gives $x = 10$, $z = 2$, $y = 8$. Assuming that the oldest child receives the one dollar less, gives $y^2 = -75$.

Also solved by *N. Barotz, Moe Buchman, R. V. Pritchard, R. C. Staley;* also several incorrect solutions which assumed the ages were 6 greater at the sixth payment than at the first payment. This would lead to the values: $x = 12$, $y = 48/5$, $z = 12/5$, $a = 35$. And if the $n$th payment is considered instead of the sixth, the values would be $x = 2(n-1)$, $y = 8(n-1)/5$, $z = 2(n-1)/5$.

III. The editor's attention has been called to the fact that this problem is the same as No. 457 proposed and solved by *Nelson R. Roray* in April, 1916. One of his solutions is of considerable interest as an example of the method of elimination:

Assuming that the ages are integers and considering the fourth equation as printed above, we see that we wish to find a fraction which will be double itself when the numerator is increased by 5 and the denominator increased by 15. Put $x+y+z = b$. The equation is then $2z/b = (z+5)/(b+15)$, or $z = 5b/(b+30)$. $z = 1$ makes $b$ fractional. Other solutions are $z = 2$, $b = 20$; $z = 3$, $b = 45$; $z = 4$, $b = 120$. All other values of $z$ make $b$ negative. Hence the only possible fractions are 2/20, 3/45, 4/120. $\therefore$ John is 2, 3, or 4 according as the sum of the ages is 20, 45, or 120. $z = 2$ gives $y = 8$, $x = 10$; $z = 3$ gives $y = 7$, $x = 35$; and $z = 4$ makes $x$ negative, and is therefore eliminated. Again $z = 2$, gives $a = 35$; while $z = 3$ makes $a$ negative, and must be discarded.

674. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*

From a cask of wine holding 10 gallons, a dishonest servant draws off a gallon each day for 20 days filling the cask each time with water. But fearing detection, he again draws off a gallon each day for 20 days, filling the cask each time with wine. How much water remained?

I. *Solution by R. V. Pritchard, Mo. School of Mines, Rolla, Mo.*

The amount of wine at end of first day is (.9) 10; at the end of the second day (.9) (.9) 10 or $(.9)^2 10$; and at the end of the twentieth day $(.9)^{20}10$. Hence the amount of water is $10-(.9)^{20}10$ or 8.784. The amount of water after the next day is (.9) (8.784), and at the end of the fortieth day is $(.9)^{20}(8.784)$ or 1.068.

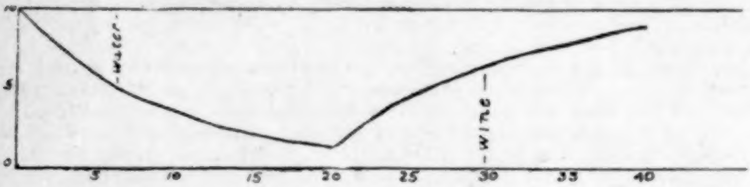
*Also solved by W. D. Baten, N. Barotz, Moe Buchman, J. Pickett, W. W. Ramsey, and Wm. F. Rigge, Creighton Univ., Omaha, Neb.*

II. *Solution by Norman Anning, Ann Arbor, Mich.*

Call the taking away of one gallon or the putting back of a gallon one operation. At the end of each of the first twenty operations there remains 9/10 of the amount of *wine* present at its beginning. Similarly at the end of each of the next twenty operations there remains 9/10 of the amount of *water* present at its beginning. This suggests the following graphical solution:

Plot number of operation as abscissa and resulting amount of wine as ordinate.

Join (0, 10) to (10, 0) cutting $x = 1$ at $(1, y_1)$.
Join $(1, y_1)$ to (11, 0) cutting $x = 2$ at $(2, y_2)$.
Join $(2, y_2)$ to (12, 0) cutting $x = 3$ at $(3, y_3)$. . . . . . etc.
Join $(19, y_{19})$ to 29, 0) cutting $x = 20$ at $(20, y_{20})$.
Join $(20, y_{20})$ to (30, 10) cutting $x = 21$ at $(21, y_{21})$. . . . . . etc.
Join $(39, y_{39})$ to (49, 10) cutting $x = 40$ at $(40, y_{40})$.
We have $y_{40}$, the final amount of wine = 9 gallons nearly.
$10 - y_{40}$, the final amount of water = 1 gallon nearly.




675. *For Undergraduates. Proposed by N. Anning, Ann Arbor, Mich.*

G is the obtuse angle of a triangle whose sides are 7, 15, 20. H is the obtuse angle of a triangle whose sides are 5, 5, 8. Prove that

$$2G + H = 360°.$$

Of the various solutions received two (by *W. F. Otto*, and *M. Kauffman*) used geometric methods, and the others trigonometric. A trigonometric method which resorts to the use of tables to determine angles, we consider a poor method; and if unnecessary angles are computed, then the method is still worse. The 3 best papers were: first, *Wilham F. Otto, W. T. Dickinson H. S., Jersey City, N. J.*, second, *Dean B. Parker, North East H. S., Kansas City, Mo.*, third, *Milton Kauffman, Wendell Phillips H. S., Chicago.* The other solutions were about on a par and are listed alphabetically: *Moe Buchman, Boys' High School, Brooklyn; Chas. Landshof, W. T. Dickinson H. S.; David McFarland, W. T. Dickinson H. S.; Olin W. Munger, North East H. S., Kansas City.*

I. *Solution by Wilham F. Otto.*

Call the triangles AGC and MHN. Let A'GC be the triangle in the *mirror* position of AGC. Let the line AA' cut CG (produced) at D. Then $(AD)^2 + (DG)^2 = 49$ and $(AD)^2 + (DG + 15)^2 = 400$. Hence DG = 21/5, and AD = 28/5, AA' = 56/5. Then $\triangle$s AGA' and MHN are similar, so that $\angle AGA' = \angle H$. But $2\angle G + \angle AGA' = 360°$; hence $2G + H = 360°$.

II. *Solution by David McFarland.*

$\cos G = (225 + 49 - 400)/210 = -3/5$ by the Law of Cosines. $\therefore \sin G = 4/5$ (positive because the angle is in the second quadrant). Similarly $\cos H = -7/25$, $\sin H = 24/25$. Then $\cos 2G = \cos^2 G - \sin^2 G = -7/25$ and $\sin 2G = -24/25$.

Then $\cos(2G + H) = \cos 2G \cos H - \sin 2G \cdot \sin H = 1$.

$\therefore 2G + H = 360°$. It cannot equal 720° because twice the sum of the angles of the first triangle plus the sum of the angles of the second triangle equal only 540°.

III. *Question by the Proposer.*

We have a triangle ABC whose sides are integral, AC = 20, BC = 20, AB = 24, and a point, D, inside whose distances from the 3 vertices are also integral, CD = 7, AD = 15, BD = 15. Are there other triangles, not merely similar to this one, with a point inside for which the distances are also integral?

## PROBLEMS FOR SOLUTION.

686. *Proposed by Norman Anning, Ann Arbor, Mich.*

Construct the acute angle whose sine is equal to its cotangent.

687. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABOC is a quadrilateral, each of the angles at A, B, and C, being 30°. A circle is drawn with O as center and OA as radius. AB, AC, and OC are produced and intersect the circle at E, F, and G, respectively. The line from F to B intersects the circle at I, and the line from E to C intersects the circle at H. Prove that arc FG equals one-fourth the arc FH, and that arc IH is 180°.

688. *Proposed by E. Kesner, Salida, Col.*

Two baseball teams, presumably of equal merit, are playing a series of games with the understanding that the first team winning four games wins the series. They have played two games, both won by A. What are the odds in favor of A's winning the series?

689. *An old puzzle.*

How high is it safe to build a pyramid of eggs, if each egg weighs two ounces and would sustain a pressure of eight pounds?

690. *For Undergraduates. Proposed by Moe Buchman, Brooklyn Boys' High School Mathematics Club.*

A train going at a certain rate meets with an accident which delays it $a$ hours. After the accident the train's rate is one $n$th less than its original rate, and it reaches its destination $b$ hours late. If the accident had occurred a distance $c$ miles farther away, the train would have been $d$ hours late. What was the train's original rate?

## SCIENCE QUESTIONS.

**Conducted by Franklin T. Jones.**

*The Warner & Swasey Company, Cleveland, Ohio.*

*Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones,* 10109 *Wilbur Ave., S. E., Cleveland, Ohio.*

**Please send examination papers on any subject or from any source to the Editor of this department.** *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Ask for the examinations you would especially like to get.**

### FOREIGN EXAMINATIONS.

The editor of this department desires to obtain examinations in NATURAL SCIENCE (as well as other subjects) from schools in France, Belgium, Italy, Spain, Denmark, Sweden, Norway and Finland. Any reader of SCHOOL SCIENCE AND MATHEMATICS in these countries will confer a great favor upon the editor by writing to him upon this subject.

### Acknowledgments.

The receipt of examination papers is gratefully acknowledged from:
R. F. Blacklock, Registrar, Dept. of Education, Regina, Saskatchewan.
S. J. Willis, Supt. of Education, Victoria, British Columbia.
The Department of Education, Edmonton, Alberta.
C. M. McCann, Department of Education, Winnipeg, Manitoba.

### TESTS.

Sometime ago tests in physics and chemistry were prepared by the editor of this department of SCHOOL SCIENCE AND MATHEMATICS. Considerable interest was displayed by correspondents at the time. Due to circumstances the writer later was not in a position to make further applications of these tests upon classes. He would appreciate further assistance and will endeavor to cooperate with any who may be interested.

357. *The following test is proposed.*

TEST M 1. COMPONENTS AND RESULTANTS.

1. Two forces of 90 pounds and 120 pounds act at an angle of 90°. What is their resultant? Ans. ..................

2. An automobile travels 50 miles an hour east. At the same time the wind blows so as to meet the machine from north-east. The weather vane stands north and south. What is the velocity of the wind? Ans. .... ...... .......

3. A stream flows south 3 miles per hour. A motorboat runs east straight across the stream. Show by diagram how the boat heads. Ans. ..................

4. A barrel of sugar weighing 300 lbs. rests on an inclined plane 7 feet long, one end of which rests on the ground, the other on the wagon bed 3½ feet above the ground. What force parallel to the plane will hold the barrel on the plane? Ans. ..................

5. What is the resultant of two parallel forces of 80 lbs. and 60 lbs. applied downwards at the ends of a horizontal rod 7 feet long? Where is it applied? Ans. ..................

The Editor tried it on himself after being out of touch with similar work for more than two years. Time, first trial, 10 min., 20 sec. After a short rest he tried again. Time, second trial, 4 min., 40 sec. *Answers* —1. 150 lbs.—2. 50 miles per hour.—3. Northeasterly—4. 150 lbs.—5. 3 feet from the force 80 lbs., or 4 feet from the force 60 lbs.

Try this on yourself and send in results. The following procedure is suggested. Prepare paper, lay test face down. At any convenient time turn test face up and begin work. Record elapsed time on completing the test. Send in your paper with results and criticisms. Results will be treated confidentially if you so desire.

358. *Here is another test. Try it in similar manner.*

TEST M 2. FORCE, WORK, AND ENERGY.

1. What force will produce in 5 seconds a change of velocity of 85 in a mass of 60? Ans. ..................

2. How much work is done when a force of 200 lbs. works through a distance of 10 feet? Ans. ..................

3. What is the energy of a piledriver tup weighing 4,000 lbs. which can fall through 18 feet? Ans. ..................

4. A punch makes a hole through a steel plate ½ inch thick meeting with an average resistance of 30 tons. How much energy is consumed in the punching? Ans. ..................

5. A hammer weighing 1 lb. has a velocity of 20 feet per second at the instant it strikes the head of a nail. Find the force which the hammer exerts on the nail if it is driven into the wood ½ inch. Ans. ..............

## EXAMINATIONS.

The Regents' Examinations of New York State are well known. The Department of Ontario, Canada, has an equally well developed system of examinations.

There has recently come to the Editor's desk a set of examinations in all subjects from Grade VIII through the high school as used by the *High School and University Matriculation Examinations Board* of the Province of Alberta.

359. It is intended in this and subsequent numbers of SCHOOL SCIENCE AND MATHEMATICS to publish complete this set of examinations as far as they pertain to science. The examination for Grade VIII is on Agriculture.

359. *Grade* VIII, *Agriculture*, 1920, *Department of Education, Alberta, Canada.*

*Time—Two hours.*

Values.

1. Suppose you have examined the face of a bank in a railway cutting or a newly dug ditch in your neighbourhood.

6 (*a*) Name and describe the different layers of soil which you would observe.

2 (*b*) Account for the difference in colour of these layers.

3 (*c*) From what materials is the upper layer chiefly formed?

6 2. (*a*) In what different ways do the following agencies contribute to the making of soils: (1) Weather, (2) plants, (3) animals?

6 (*b*) What are the chief constituents of each of the following soils: Sandy soil, sandy loam, clay loam?

3 3. (*a*) Distinguish between free and capillary water in the soil.

2 (*b*) Of what importance is capillary water in the soil?

3 (*c*) Give reasons for what happens when a low part of a field which has been seeded for a short time is flooded for several days by a heavy rainfall.

4. The candidate is supposed to have performed the following experiments:

Take three empty tomato cans of the same size and make a few holes through the bottom of each with a nail. Fill one of the cans with finely pulverized air-dried humus, one with clean air-dried sand and the other with finely pulverized air-dried clay.

Tamp the soil in each can to the same degree by tapping the bottoms of the cans on the table and have each can after tamping filled to within half an inch from the top. Weigh each can and record the weights.

Support each can on three uniformly sized blocks on the table.

Pour water slowly into each can until the soil is thoroughly saturated and the water drips freely from the holes in the bottoms of the cans.

Allow the cans to stand until they stop dripping and again weigh them and record the weights.

2 (1) Compare the weights of the cans before and after saturation.

2 (2) Which soil increased the least in weight due to saturation with water?

2 (3) Which one increased by the greatest amount?

3 4. (4) What would you conclude regarding the moisture holding capacity of the three soils?

2 (5) Which of the three soils is made up of the finest particles?

2 (6) What effect has the fineness of a soil on the amount of water it will retain?

4 5. (*a*) Give a short account of the way in which plants may be improved by selection.

4 (*b*) Name four plants which are legumes.

3 (*c*) Give three reasons why the growing of legumes is of great importance to the farmer.

3 (*d*) What are the conditions necessary for the best results from the activity of bacteria in the soil?

5 6. (*a*) State five important objects of tillage.

10 (*b*) Give reasons for the attaining of the objects asked for in (*a*).

2 7. (*a*) What kind of soil is chiefly found in your neighborhood?

6 (*b*) State one suitable crop rotation for it.

4 (*c*) What are the chief principles which should be observed in making a crop rotation?

5 8. (*a*) Describe fully how the farmer tests his seed grain before sowing it and state for what purposes he tests it.

5 (*b*) Describe the life history of a cutworm and give an effective method for controlling its increase.

5 (*c*) Name one bird which destroys insects in the grub stage, one which lives on insects which infest the bark of trees, one which eats insects living in the trunks of trees, one which hunts insects which live on the leaves of trees and one which catches insects while flying in the air.

OR

Write full notes on any *three* of the following subjects designated

(*a*), (*b*), (*c*), (*d*), (*e*), below:

5 (*a*) How to prepare a plot for growing beets for table use; the depth to which the seed should be sown; how to cultivate the soil while the plants are growing; when to thin the plants; and how best to keep them for winter use.

5 (*b*) How to prepare the soil for growing sweet peas; how to sow the seed; how to care for the plants while growing to obtain the best sample and the greatest yield of flowers; how to tastefully arrange a bouquet of the flowers for exhibition at the school fair.

5 (*c*) How to set and care for a hen while brooding; how to care for the chicks for the first few days after hatching; the care you would give them until they are well grown.
Which breed of chickens would you raise for egg-laying purposes?

5 (*d*) (1) How to care for a calf which you are raising for exhibition at the school fair.
(2) Name one breed of cattle which is a good beef-producer, one which is good for dairy purposes and one suitable for both beef and dairy purposes.

5 (*e*) How to prepare the soil for growing trees for a shelter belt; the kinds of trees you would plant; how you would plant them and at what distances apart; how they should be cared for during the first two years after planting.

## CLASSROOM SAYINGS.

A chemical element is when the substance or quality of the element has not been deprived of its simple composition.

Put in a mortar and grind with a pedestal.

Air contains 1 per cent Argonne and other rare gases.

Rubber burning forms rubber oxide.

Aluminum is made of a yellowish clay called bucksite.

Carbon dioxide is the thrower off from the body.

Water vapor aids in drying the preparation of the body.

Air is weighted in a blub to find its composition.

Oxygen can be separated from nitrogen by using something that has an infinitive for oxygen.

Three organic substances found in water are ammoniums, harmful salts or sulphates, and harmful bacteriaisms.

A good baking powder is one that contains good materials, for example marble instead of limestone.

Daylight saving is setting the clocks ahead one hour so as to get more rise out of the daylight.

The ocean furnishes water, transportation, fish, furs, tides to keep the shore clean, currants, and on the shores are canaries.

Vitamines are tiny living creatures that live on the husks of rice.

New York is sometimes called "The Vampire State."

1619—Invention of Slavery.

Washington was irrigated in 1789.

1620—Plymouth was settled by Jamestown.

The equator is a menagerie lion running around the earth.

Why has the Pacific coast very few good harbors? Because there aren't many around there.

Scientifical force is a force produced in water falls.

Centrailar force is the acting force which causes the outside force to be greater than the inside force of a certain place.

How is this for logic?

My dear Mr. Smith:

Kindly allow my son to drop Miss Jones and Mr. Brown as teachers allowing him to take others in their place, owing to the fact that he works every night and must have more sleep. (Signed) A FATHER.

## REPORT OF COMMITTEE ON THE REORGANIZATION OF SCIENCE IN THE SECONDARY SCHOOLS.[1]

A committee consisting of forty-seven science teachers has been working for over seven years upon the "Reorganization of Science in the Secondary Schools." The committee was organized with a small supervisory committee and subcommittees, representing each of the sciences included in the report. Conferences concerning the material to be included in the report have been held in all parts of the country in order that the freest possible discussion might be secured. Studies have been made of progressive experiments in science teaching in many schools, and the results of these experiments have been included in the report. Due to these conferences and to the progressive work upon which they were based much of the material included in this report has been already incorporated into the practice of many schools. Therefore, the report is not so much an argument as to what ought to be done in the schools as it is a record of work already accomplished by progressive science teachers.

Some of the topics covered in the report are:

The aims, methods, and organization of the sciences as a whole in secondary education; General principles governing the selection of material and its presentation; Science sequences recommended for various types of schools; the principal courses in science—General science; Biological sciences; Chemistry; Physics; and, The Science Teacher. Each of the preceding topics is treated under a detailed outline, and with abundant reference to contents of courses and methods of presentation.

Probably the following quotation from the preface will give the best impression of the general nature of the report:

"The committee on science of the Commission on the Reorganization of Secondary Education has carried on its work by means of discussions, correspondence, and formulation of preliminary reports for over seven years. The discussion of preliminary reports by groups, committees, and at meetings of science teachers has revealed progressive work already under way and has led to the trial of preliminary recommendations. Some of the improvements that the committee sought to effect have already been adopted by many of the best schools. The full report[1] herein presented, formulated through this procedure, incorporates practices that have proved most useful. It asks for only those features of reorganization that have been found to work well, or which by a fair amount of trial promise improvements. Further experiments with new courses in science, or with the readjustment of older courses, may make desirable and necessary a revision of the report before many years have passed.

"The report embodies contributions and criticisms of more than 50 science teachers and administrative officers. It does not include every proposal, as some such proposals are not fully approved by others. Some members of subcommittees have been unable to send criticisms of the full report, but because of their previous important work on subcommittees their names are included in the list of members.

"OTIS W. CALDWELL,
"Chairman Committee on Science.
"CLARENCE D. KINGSLEY,
"Chairman of the Commission."

[1]This report has just appeared as "Bulletin No. 26, 1920, United States Bureau of Education," and may be secured from the Superintendent of Documents, Washington, D. C., at ten cents per copy.

## DELAWARE THE LOWEST STATE.

The average elevation of Delaware is only 60 feet above sea level, according to the United States Geological Survey, less than that of any other State in the Union, although its highest point, at Centerville, New Castle County, is 440 feet above sea level, higher than the highest points in Florida, Louisiana, and the District of Columbia.

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## NATIONAL FORESTS WILL AID ALASKAN DEVELOPMENT.

The national forests of Alaska offer the best key to unlock the great resources of that Territory, according to the Secretary of Agriculture in his annual report to the President. Practically all of the most valuable timber in Alaska is still owned by the Government and is already playing an important part in the industrial development of the region. The mills cutting national forest timber are now furnishing nearly all the lumber used in the Territory, while the location of pulp mills in the national forests will greatly aid in solving the problem of our future supply of newsprint paper. Decentralized administration, however, is necessary to obtain the best results, the Secretary says.

"The Department of Agriculture, in connection with a number of other departments, has very definite responsibilities in connection with Alaskan development," the report states. "It is endeavoring, for example to increase the production of crops and live stock; it has experts in the field investigating the possibility of building up the reindeer herds into an important source of meat supply; it is giving attention to the perpetuation of the fur industry. But its chief responsibility at the present time is in connection with administration of the national forest in Alaska. Under regulated use the Tongass National Forest alone can probably produce forever 1,500,000 tons of newsprint yearly, along with ample quantities of timber for local purposes."

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## TWO IMPORTANT REPORTS OF INTEREST TO ADMINISTRATORS AND TEACHERS.

By Earl R. Glenn

*The Lincoln School of Teachers College, Columbia University.*

*Outline.*

I. Science in the Secondary Schools of Great Britain.

a. Science in the secondary school.
b. Science course, ages 12 to 15.
c. Science course, ages 16 to 18.

II. Science in the Secondary Schools of America.

a. Science as a whole in secondary education.
b. Contribution of science to general education.
c. Science sequences recommended.
   1. Junior-senior high school.
   2. Large four year high school.
   3. Four year high school of medium size.
   4. Small high school.
d. The principal courses in science.
e. The science teacher.
f. Defects and remedies in education.

## I. Science in the Secondary Schools of Great Britain.

Those who desire to make science function in the education of pupils of high school age will find many valuable suggestions in two recent reports dealing with the reorganization of science in secondary schools.

The first report,[1] which was published more than two years ago but has received almost no attention in American journals, is entitled, "Natural Science in Education," and is a report of the Committee on Natural Science in the Educational System of Great Britain. This committee was appointed by the Prime Minister in August, 1916, and issued its report in 1918. Sir J. J. Thomson, who is well known for his great discoveries in physics, as well as for his interest in public affairs, was chairman of the committee which was appointed to advise what measures are needed to promote the study of science with respect to the needs of a liberal education, to the advancement of pure science, and to the development of the trades, industries, and professions which depend upon applied science.

The final report is a volume consisting of 272 pages which represents the labor of many able men and women. The importance of this report has been appreciated by the United States Bureau of Education and almost the entire report[2] has been reprinted by the Government Printing Office.

We quote a few statements from the "Summary of Principal Conclusions" (Chapter VI, pages 237-8).

### (a) Science in the Secondary Schools.

"Steps should be taken to secure for all pupils in state-aided secondary schools a school life beginning not later than 12 and extending at least to 16.

"In all secondary schools for boys, the time given to science should be not less than 4 periods in the first year from 12 to 16, and not less than 6 periods in the three succeeding years.

"Increased attention should be given to the teaching of science in girls' schools.

"In girls' schools with a 24-hour school week not less than 3 hours per week should be devoted to science in the period 12-15."

### (b) Science Course, Ages 12 to 15.

"The science work for pupils under 16 should be planned as a self-contained course, and should include besides physics and chemistry, some study of plant and animal life.

"More attention should be directed to those aspects of the sciences which bear directly on the objects and experiences of every day life.

"There should be as close correlation as possible between the teaching of mathematics and science at all stages in school work.

### (c) Science Course, Ages 16 to 18.

"The amount of time devoted from 16 to 18 to the subject or subjects in which a pupil is specializing should be not less than one-half or more than than two-thirds of the school week.

"Those specializing in science should continue some literary study, and those specializing in literary subjects should give some time to science work of an appropriate kind.

"Pupils who do advanced work in science should be enabled to acquire a reading knowledge of French and German."

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[1]Thomson, Sir. J. J., and Committee, Natural Science in Education, His Majesty's Stationery Office, London. Price 1s. 6d.

[2]Natural Science Teaching in Great Britain, Bulletin 1919, No. 63. Government Printing Office, Washington, D. C. Price 15 cents.

### II. Science in the Secondary Schools of America.

The second report[3] to which we wish to refer is a more recent publication entitled "Reorganization of Science in Secondary Schools." This bulletin is one of the reports issued by the Commission on the Reorganization of Secondary Education. This American report was prepared by a science committee of 47 members with Professor Otis W. Caldwell of Teachers' College, Columbia University, as Chairman. The work of this Committee has been in progress for seven years and now that the report has been approved by the Reviewing Committee of the Commission on the Reorganization of Secondary Education, the report is issued for public distribution.

#### (a) Science as a Whole in Secondary Education.

The report states that there is great need for reorganizing the science courses of the secondary schools because of:

1. The variation of purposes for which the sciences are taught.
2. The increasing number of sciences offered.
3. The development of intensive specialization within the sciences.
4. The lack of sequence in the order of teaching the various sciences.
5. The wide variation in content and method.

#### (b) Contribution of Science in General Education.

The Committee suggests that science instruction should contribute to six chief objectives in general education as follows:

1. *Health:* Topics dealing with health should be taught in the junior high school, and in at least the first and second years of the four year high school.

2. *Worthy home membership:* The conveniences that make the modern home comfortable and attractive require science for their full appreciation and intelligent use.

3. *Vocation:* Science should be so presented as to be of direct assistance in the wise selection of vocation.

4. *Citizenship:* Students should acquire a more intelligent appreciation of the services rendered by the scientist and technologist.

5. *Use of leisure time:* Science should be taught so as to suggest useful and pleasurable avocations.

6. *Ethical character:* The science course should contribute to an adequate conception of truth and a working confidence in the laws of cause and effect.

#### (c) Science Sequences Recommended.

1. Junior-Senior high school—Seventh year: General science, hygiene included, three periods per week.

Eighth year: General science, hygiene included, three periods per week.

*Note:* In case general science is not carried through seventh and eighth grades it may be given five periods per week.

Ninth year: Biology, including hygiene. Courses may consist of general biology, botany, or zoology.

Tenth year, eleventh year, twelfth year: Elective courses as follows:

a. Chemistry—General chemistry and special courses.
b. Physics—General physics and special courses.
c. General geography or physiography.
d. Advanced biological science.

2. Large four year high school:

First year—General science, including hygiene.

[3]Caldwell, Otis W., and Committee, Reorganization of Science in Secondary Schools, Bulletin 1920, No. 26. Government Printing Office, Washington, D. C. Price 10 cents.

Second year—Biology, including hygiene. Courses may consist of general biology, botany or zoology.

Third year and fourth year—Elective courses as follows:

a. Chemistry.

b. Physics.

c. General geography or physiography.

d. Advanced biological sciences.

3. Four year high school of medium size:

First year—General science.

Second year—Biology.

Third year—Chemistry.

Fourth year—Physics.

4. Small high school:

First year—General science.

Second year—Biology.

Third year and fourth year—Chemistry and physics. It is desirable to alternate the courses in chemistry and physics in alternate years.

(d) The Principal Courses in Science.

Part II of the reports concerns the details of the principal courses in science, namely: general science, biology, chemistry, and physics. Several pages are devoted to each science in discussing the selection and organization of subject matter, methods of teaching, type, topics, aims, excursions, etc.

(e) The Science Teacher.

At the end of the report, there is a brief appendix dealing with the science teacher, his training, and professional development.

(f) Defects in American Education and the Remedies for Them.

In discussing the defects in American education[4], a well-known educator mentions:

1. Bad diet.
2. Infant mortality.
3. Feeble efforts of state and nation in combating tuberculosis.
4. Popular ignorance of venereal diseases.
5. Lack of manual skill.
6. Little training of the senses.
7. No habitual accuracy of observation or statement.

Finally, for the first time in the history of high school science, we have two reports issued by independent committees of two great nations, in which practically the same science program is advocated for the secondary schools of the respective nations. If the suggestions of these committees could be put into intelligent operation at once, the defects mentioned above might be remedied in an effective manner in a reasonable length of time.

[4]Eliot, Charles W., Certain defects in American education and the remedies for them. Teachers Leaflet, No. 5, Bureau of Education, Washington, D. C.

## ARTICLES IN CURRENT PERIODICALS.

*American Mathematical Monthly*, for December; *Lancaster, Pa.:* $4.00 *per year*, 60 *cents a copy:* "Retrospect and Prospect for Mathematics in America," Presidential Address, H. E. Slaught; "The Graphical Solution of Spherical Triangles," H. C. Bradley; Questions and Discussions: Questions—Replies to question 34 by A. A. Bennett and W. A. Hurwitz; Discussions—"Geometrical Proofs of the Law of Tangents," by W. V. Lovitt; "Note on the Law of the Mean" by H. H. Downing; Recent

Publication: Reviews—By F. Cajori, E. J. Moulton, etc.; Notes; Articles in Current Periodicals; Problems and Solutions: Problems—2862-2868; Solutions of Problems—2790.

*Condor*, for November-December; *Eagle Rock, Los Angeles, Calif.*: $2.00 *per year*, 40 *cents a copy:* "The Wing Claw in Swifts," Alexander Wetmore; "Nesting of the Olive-sided Flycatcher in Berkeley, California" (with three photos), Joseph Dixon; "The Probable Breeding of the Aleutian Tern in Southeastern Alaska—a Query," F. S. Hersey; "Comments upon the Safety of Sea Birds and upon the 'Probable' Occurrence of the Northern Bald Eagle in California," G. Willett; "Some Nesting Habits of the Pied-billed Grebe," Griffing Bancroft; "Notes on the Calliope Hummingbird," L. E. Wyman.

*Journal of Geography*, for December; *Menasha, Wis.*: $2.00 *per year*, 25 *cents a copy:* "Calamarca: The Arizona of Argentina," Jehiel Davis; "Man and His Work," Anne Devany; "Road Improvements at Foochow, China," Walter N. Lacey; "Island Life," F. Hamburg.

*National Geographic Magazine*, for January; *Washington, D. C.*: $4.00 *per year*, 50 *cents a copy:* "The Dream Ship" (44 illustrations), Ralph Stock; "Treasure-House of the Gulf Stream" (5 illustrations), J. O. La Gorce; "Sixteen Color Plates of Warm-Sea Fishes," Hashime Murayama; "Interesting Citizens of the Gulf Stream" (13 illustrations), John T. Nichols; "Every-Day Life in Afghanistan" (27 illustrations), Frederick Simpich and Haji Mirza Hussein.

*Nature-Study Review*, for December; *Ithaca, N. Y.*: $1.50 *per year*, 20 *cents a copy:* "The Canvasback Duck," L. F. Brotherhood; "The Ruffed Grouse," S. J. Wilkin; "The Mallard," G. G. Wurzberger; "The Woodcock," M. Jackson; "How to Study Game Birds," "The Spotted Turtle," R. W. Shufeldt; "Common Snakes," E. B. Whiting; "Bird Migration by White of Selbourne," C. I. Thomas; "Notes on Birds' Structure and Habits," J. Traver.

*Photo-Era Magazine*, for January; *Boston, Mass.*: $2.50 *per year*, 25 *cents a copy:* "The Camera in the Windward Islands" (Part Two), Herbert B. Turner; "Method of Producing Reversed Dye-Images," J. I. Crabtree; "Use of the Mirror in Portrait-Photography," Atelier; "An Efficient Developing-Tank," Bertha Morey; "Method of Correcting Harsh and Halated Negatives," Thermit; "Simple Film Negative-Holder," H. P. T. Matte; "Still-Life Photography," William S. Davis; "Fundamentals of Print-Criticism and Appreciation" (Part One), August Krug; "Weather-Conditions and Darkroom-Work," The Photographic Dealer.

*Popular Astronomy*, for January, *Northfield, Minn.*: $4.00 *per year* "Report on Mars, No. 23," with Plates I, II and III, William H. Pickering; "The Limit of the Astronomical Telescope, Part II, G. A. Shook; "Twenty-Fourth Meeting of the American Astronomical Society" (Continued); "Passing Through the Ring-Plane of Saturn," Mary Murray Hopkins; "Astronomical Phenomena in 1921."

*School Review*, for January; *University of Chicago Press:* $2.50 *per year*, 30 *cents a copy:* "Educational News and Editorial Comment"; "Studies in High-School Procedure—Direct and Indirect Teaching," Henry C. Morrison; "The Status of Vocational Guidance in Massachusetts, April, 1919," Louis A. Maverick; "The Teaching of Mathematics in the Junior High School," E. R. Breslich; "Rating Scales, Self-Analysis, and the Improvement of Teaching," William S. Gray.

*Scientific Monthly*, for January; *Garrison, N. Y.*: $5.00 *per year*, 50 *cents a copy:* "The Earth Sciences as the Background of History," Dr. John C. Merriam; "Reshaping our Forest Policy," J. W. Toumey; "Controlling the Airplane at Twenty Thousand Feet," Henry C. McComas; "Surveys of the Intestinal Protozoa of Man in Health and Disease," Dr. R. W. Hegner and Dr. George C. Payne; "On the Character of Primitive Human Progress," R. D. Carmichael; "Selection—An Unnoticed Function of Education," W. B. Pillsbury; "The Group-Theory Element of the History of Mathematics," G. A. Miller; "The Oldest of the Forests," Dr. John M. Clarke.

## QUICKSILVER IN IDAHO.

Although Idaho has never been a considerable producer of quicksilver it has from time to time yielded a few flasks —enough to arouse interest in the character of the deposits and their possible economic future. The district in which the most activity has been shown is the Yellow Pine, in Valley County, about 50 miles northeast of Cascade. This district has recently been examined, under a cooperative arrangement, by E. S. Larsen, of the United States Geological Survey, Department of the Interior, and D. C. Livingston, of the Idaho State Bureau of Mines and Geology. Their report, published as Bulletin 715—E of the United States Geological Survey, describes briefly the geology of the district and the principal known deposits of quicksilver ore. Mining development, although some of the deposits have been known for nearly 20 years, is still in an early stage. The ore, mainly cinnabar, occurs chiefly in limestone near the contact of that rock with quartzite. No large masses of ore have yet been blocked out, but the prospects for future production are regarded as fairly good. The most serious handicap to development has been the remoteness of the district from the main lines of transportation. The wagon road from Cascade is 70 miles long and has steep grades and a generally rough surface.

The report, which is entitled "Geology of the Yellow Pine Cinnabar-Mining District, Idaho," may be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

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## MONGOLIA.

"Mongolia, a land of contrasts—of camel caravans and motor cars skin huts and telephones—now is one of the least known of Asiatic countries, but gives promise of a rich future," says a bulletin of the National Geographic Society based on a communication by Roy Chapman Andrews.

"It is tucked away beyond the northern border of China proper and is conceived of by many as largely made up of the Gobi Desert, which doubtless has the reputation of being one of the most desolate wastes in the world. As a matter of fact much of this 'desert,' while parched prairie in the late summer, is covered with succulent green grasses in the spring. It is closely comparable to the plains of Kansas and Nebraska. This prairie country is excellent grazing land and supports numerous herds of antelope, and also furnishes pasture for large numbers of horses, cattle, sheep and goats.

"The Mongols were once such hardy and efficient warriors that they subdued and ruled all Asia and part of Europe. They are still physically fit and capable of standing privations and hard service, but they are in the grip of a pernicious and enervating religion—Lamaism, a degenerate Buddhism introduced from Tibet in the thirteenth century. This religion of superstitions and degrading practices has created a vast army of priests and monks who live in squalor in groups of thousands about the temples and monasteries. In the holy city of Urga, capital of Mongolia, 15,000 priests abide in huts clustered around three temples.

"The streets of Urga resemble a circus or the stage at the Hippodrome. The women wear costumes as ornate as any to be found in the world. Their hair is 'ratted' a foot or more on each side of their heads, rouge-like sploches are placed on their cheeks to denote their ranks, and their gowns are of brocaded cloth in brilliant colors.

"Most picturesque of countries, Mongolia is also the most benighted in some respects. The cruelties practiced in the prisons are almost unbelievable. Convicts are confined in coffin-like boxes, too low to allow

them to sit upright, and too short to permit them to lie at full length. The 'long-timers' frequently suffer atrophy of the arms and legs.

"In their method of disposing of their dead the Mongols are almost savage. The bodies are taken to an isolated spot and fed to dogs. As one result the wolf-like dogs of the country are very ferocious and when the opportunity presents itself they will attack living persons.

"In traveling from Peking to Urga we crossed the Gobi Desert in motor cars. We passed many camel caravans, furnishing a most striking contrast in methods of transportation. Much of the 'desert' near China proper has been reclaimed by the Chinese who grow grains and potatoes successfully.

"By using our motor cars to chase antelope over the level plateau and noting on our speedometers the speeds attained, we established the surprising fact that these creatures can run at the rate of sixty miles an hour. At such speeds the rapidly moving legs of the antelope become a mere blur like the whirling blades of an electric fan. The bodies of the animals seem to be floating at a terrific rate a few feet above the surface of the ground."

## EASTERN ASSOCIATION OF PHYSICS TEACHERS.

By A. B. Stanley.

At the joint meeting of Science Teachers of New England, Saturday, December 4, at Boston University, a number of very good pieces of new apparatus were demonstrated. Mr. Cowen of West Roxbury High School took a spiral curtain spring and attached it to a scale pan to illustrate Hooke's Law, and to find the comparative extension of the spring with the load in air and under water.

He also showed an excellent method for giving the students a quantitative idea of the amount of gas consumed by an ordinary gas-light, using a one gallon bottle with a tubulature at the base. In a two-hole rubber stopper in the neck, were inserted a manometer and a bent piece of glass tubing. A large figure on the front of the bottle, showed that its capacity was 1-8 of a cubic foot. The bottle was first filled with water through the tubulature, then the bent glass tubing at the top was connected to the source of gas supply, and the water allowed to run out until it reached the mark which indicated that 1-8 of a cubic foot of gas had been drawn in. When the water was shut off by a pinchcock, the pressure indicated by the manometer was read. This will vary in different places, but it will be between 2 and 4" of water. The rubber tubing through which the gas entered the bottle, was then disconnected from the source of supply, and attached to an ordinary gas burner, giving a yellow flame, and the rubber tubing through which the water was allowed to run out of the bottle was attached to the water faucet and the water turned on with such force that the manometer indicated the same pressure at which the bottle was filled with gas. The burner was lighted. At the time when the gas began to flow out of the bottle, the observer noted the time and recorded the number of seconds which it took the burner to consume the 1-8 cubic foot of gas. The operation may be repeated, using a Welsbach burner and then the results compared. A very interesting set of figures, full of practical value to the students may be compiled by studying the time which one cubic foot of gas will supply an ordinary burner, a Welsbach Junior burner, and the Regular Welsbach mantle.

All of the material for this second experiment can be obtained from the L. E. Knott Apparatus Company. See their advertisement on page 205 of this magazine.

## BOOKS RECEIVED.

Lessons in Mechanics. A text-book for colleges and technical schools by William S. Franklin and Barry MacNutt. Pages xi+221. 14.5x22 cm. Cloth. 1919. $2.00.

Lessons in Heat, by same author. Pages xi+147. 14.5x22 cm. Cloth. 1920. $2.00.

Lessons in Electricity and Magnetism, by same author. Pages xvi+254. 14.5x22 cm. Cloth, $2.25. 1919. Franklin and Charles, Bethlehem, Penn.

The Elements of Theoretical and Descriptive Astronomy, by Charles J. White and Paul P. Blackburn, Commander U. S. Navy. Pages xi+309. 13.5x20.5 cm. Cloth. 1920. $3.00 net. John Wiley and Sons, New York City.

Introductions to General Chemistry, by H. Copaux, School of Industrial Physics and Chemistry, city of Paris. Translated by Henry Leffmann. Pages x+195. 12x18 cm. Cloth. 1920.

Bureau of Educational Research, University of Illinois, First Annual Report; B. R. Buckingham, Director. 78 pages. 15x22.5 cm. Paper. 1919. 25 cents.

Mental Tests for School Use, by Charles E. Holley, University of Illinois. 91 pages. 15x22.5 cm. Paper. 1920. 50 cents.

Standard Requirements for Memorizing Literary Material, by Velda C. Bamesberger, University of Illinois. 93 pages. Paper. 1920. 50 cents. The University of Illinois Press, Urbana.

Statistics of Public High Schools, 1917-18, by H. R. Bonner, Bureau of Education, Bulletin, No. 19, 1920. 192 pages. 15x23 cm. Paper. 1920. 25 cents. Government Printing Office, Washington.

## ADDENDA WANTED.

The treasurer of the Central Association of Science and Mathematics Teachers would like to have the addresses of Emma C. A. Kermann, receipt No. 181, and of W. A. Stevenson, receipt No. 264, to the end that they may receive this magazine to which they are entitled. Send addresses to Lewis L. Hall, Treasurer, 11316 S. Oakley Ave., Chicago.

## GYPSUM DEPOSITS IN THE UNITED STATES.

A bulletin describing the gypsum deposits in the United States has just been issued by the United States Geological Survey, Department of the Interior. Gypsum is the rock used for making plaster of Paris and hard wall plaster, and it is also an ingredient of Portland cement and is used as a fertilizer. The bulletin shows that gypsum is distributed from New York to California and from Michigan to Texas. The deposits in some States are so small that they may be worked out in a few years; those in other States, like Wyoming and New Mexico, consist of thick beds that crop out at the surface for hundreds of miles and that are seemingly inexhaustible. The bulletin contains 325 pages and many illustrations and includes a technical discussion of the physical and chemical properties of gypsum, a classification of the deposits by origin, a history of the gypsum industry in the United States, and a brief description of processes of mining and milling, as well as a bibliography, but it consists principally of descriptions of the deposits, by States, written by State geologists and others who are thoroughly familiar with them. The book, which is published as Bulletin 697 of the U. S. Geological Survey, was compiled and in part written by R. W. Stone, a geologist who has made a special study of gypsum. A copy can be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

## BOOK REVIEWS.

*Common Science, by Carleton W. Washburne, Superintendent of Schools, Winnetka, Ill.* Illustrated with 191 photographs and drawings. Pages xv—390. 14×19 cms. Cloth. 1920. $1.60. World Book Company, Yonkers-on-Hudson, New York.

This is a very unique book on general science and one in which younger people in high school will be particularly interested. It is written from different points of view from the other current texts on general science. The foundation of the book really was made by culling out several hundred questions that were asked of pupils in the elementary grades; so, in a sense of the word, the book is an evolution from the minds of the youngsters who are expected to use it.

It is written in a language such that children can understand. The illustrations and drawings are practically all original and there are very many clever halftones in the text. The statements are accurate and to the point. It contains a great deal of practical information that seventh and eighth graders should know about. The reviewer is confident that it will meet the needs of science work in the seventh and eighth grades. Mechanically the book is splendidly made and will stand hard usage.

C. H. S.

*Regents' Questions and Answers in Physics, Regents Publishing Company.* 112 pages 12½×16½ cms. Paper. 1920. 60 cents. Regents Publishing Company, 32 Union Square, New York City.

It is a compilation of questions in physics taken from the more recent regent examination papers. It is up-to-date, the questions are classified under the several heads under which physics is taught. Each question is followed by a very complete answer and in many cases, where possible, a cut explaining the answer is given. The book will be valuable in the hands of physics teachers in preparing pupils for entrance examinations and also for class review exercises. C. H. S.

*Regents' Examination Questions and Answers in Chemistry.* 96 pages. 12½×16½ cms. Paper. 1920. Regents Publishing Company, 32 Union Square, New York City.

What was said with reference to the preceding book can be said with reference to this one. It is intended to cover the requirements of a high school course in chemistry. Pupils being able to pass test questions here given would be able to pass entrance examinations in chemistry in practically any institution. The questions are classified by groups and answers are given following each question. A valuable book for all secondary teachers in chemistry. C. H. S.

*Scientific Instruments and Laboratory Supplies, Standard Scientific Company.* 240 pages. 18×25 cms. Paper. 1920. Standard Scientific Company, 147 Waverly Place, New York City.

This is a catalogue recently issued by this enterprising firm telling by description and drawing about the various pieces of apparatus with which this firm deals. The price at the time of issuing the catalogue is given. Some interesting pieces of new apparatus are mentioned. As a general thing, the cuts are placed on the left-hand page while the description and price are on the right-hand. Published on good quality paper, and contains a complete finding index of apparatus as well as supplies.

C. H. S.

*Balopticons and Accessories, Bausch & Lomb Optical Co.* 99 pages. Paper. 1920. Bausch & Lomb, Rochester, N. Y.

This is a most interesting and helpful catalogue, describing completely the various lanterns and accessories manufactured by this enterprising and well-known firm. There are no better lanterns and projection apparatus made than are put on the market by this institution.

Descriptions of all of their various makes of lanterns are made here. The terms of payment and shipment are described; diagrams showing the course of the rays of light from its source through the lantern are given. The catalogue number, description, and price are all given. Any person or school thinking of purchasing projection apparatus cannot do better than to order from this firm. C. H. S.

*Studies in Minor Folds, University of Chicago.* Pages ix—99. 17½×24½ cms. Cloth. 1920. $1.65. University of Chicago Press.

This is a unique volume devoted to one particular phase of geological study. There are 44 figures, nearly all halftones, and three zinc plates. There are 18 tables of collected data. Comparatively little attention has been given to this phase of geology; that is, where the studies have been described in such a clear and straight-forward manner as in this volume. It is so well-written that the ordinary layman cannot help but be interested in reading the book. It is a text that every teacher of Geology should possess and study. C. H. S.

*The Airplane, by Frederick Bedell.* Pages 256. 15½×23½ cms. Cloth. 1920. $3.00. D. Van Nostrand Co., New York City.

One of the finest and best texts that have recently come from the press, descriptive of the theory and practice of airplane work. No one is better equipped to write on this subject than the author of the book. There are 115 well-executed illustrations. It is not a book for the ordinary layman to read, though he can become familiar with most of it. There are 13 chapters, each discussing a particular phase of airplane work. It is splendidly written; it is a book of authority and one which people with a fair knowledge of airplane theory should possess and study. There is a complete index and a glossary explaining the various words used in the book.

It is printed on uncalendered paper, thus avoiding the glare of reflection, and it is mechanically well made. C. H. S.

*Story of the American Red Cross in Italy, by Charles M. Bakewell.* 253 pages. 13½×19½ cm's. Cloth. 1920. McMillan Company, New York City.

This is a compilation of descriptions of some of the various activities conducted by the Red Cross in Italy during the recent Great War. It is not a detailed statistical report, but rather tells to the American people what was done by this organization with the funds which they so generously contributed.

The Red Cross went into Italy at a time of its greatest need, and they rendered very material aid to the Italian army and it is undoubtedly due largely to the aid received from the American Red Cross which finally caused the Italian army to be so wonderfully successful. The aid rendered, without question, brought at that time the Italian people in closer touch with the American folk than they had ever been before.

It is a book that is well worth while for every contributor to the Red Cross, at least, to read, and it would be well for every loyal American citizen to get it and read it. C. H. S.

*The Passing Legions, by George B. Fife.* 369 pages. 13½×19½ cms. Cloth. 1920. The MacMillan Co., New York City.

This is a most delightful and entertaining book on the activities of our soldiers and people in the various commissions in Europe during the Great War. The writer has produced a book which will open the eyes of the reader a little more fully to the splendid work done by the various societies formed for the purpose of supplying our boys with some of the comforts and pleasures of life which the army was unable to furnish. It is a book that our American public should get and read. C. H. S.

*Lessons in Mechanics, by William S. Franklin and Barry McNutt, Bethlehem, Pa.* Pages xi—221. 14½×22 cms. Cloth. 1919. $2.00. Franklin and Charles, Bethlehem, Pa.

This book, and its companion volume, "Lessons in Electricity and Magnetism," have been written to meet the needs of a two year course in elementary physics, and especially to be used in technical schools. It is a splendid exhibition of the way in which physics of today should be taught.

A knowledge of mathematics is not excluded, and the mathematics is of such a nature that the union of mathematics and physics on these subjects is essential for a clear understanding on the part of the pupil of the real physics which he is studying.

The texts are primarily to be used to make the classroom work as efficient as possible. References to important, helpful books are given, also a page is devoted to the various engineering societies.

The drawings are practically all new and original; it is written in such a way that the pupil will understand the matter with the least amount of effort. There are numerous practical problems scattered throughout the text. The book is printed on not very highly calendered paper, thus reducing the glare of reflection.

There are pages devoted to a comparison between translatory motion, rotary motion, and electrical motion.

There is one bad feature in the opinion of the reviewer, and that is that the answers are given to the problems.

There is a complete index in both books. These are texts that will be well worth while for instructors in technical schools to adopt for their classes. C. H. S.

*Lessons in Heat, by William S. Franklin and Barry McNutt, Bethlehem, Pa.* Pages xi—147. 14½×22 cms. Cloth. 1919. $2.00. Franklin and Charles, Bethlehem, Pa.

What has been said of the two preceding books may well be said of this one. This surely is a most excellent treatise on the theory of heat from all points of view, as far as elementary physics are concerned.

The book ought to have a wide circulation. C. H. S.

*With the Doughboy in France, by Edward Hungerford.* 291 pages. 13½×19½ cms. Cloth. 1920. MacMillan Company, New York City.

A most interesting book, well worth while for any one interested in the American soldier to carefully read and study. It is written from the point of view of one who witnessed one of the biggest things in humanitarian effort ever undertaken, namely, the work of the Red Cross during the war.

Mr. Hungerford has secured this information from many sources. C. H. S.

*The Elements of Theoretical and Descriptive Astronomy, by the late Charles H. White, formerly professor of mathematics, Harvard University. 8th edition revised by Paul B. Blackburn, Commander United States Navy.* Pages ix+309. 14½×21 cms. Cloth. 1920. $3.00. John Wiley and Sons, New York City.

The fact that this book has been able to live until its eighth revision is praise enough of its worth. It has been recently revised and brought down to date. It contains the main facts and principles for an elementary course in astronomy.

While written primarily for college work, it can be very nicely used in the senior year in high school. There are no material changes in this present edition over the forms adopted by the original author.

The book contains eighty-four figures and a number of halftones of astronomical apparatus and of various comets. Major paragraphs

begin with bold face type, which tells one of the subjects treated in that paragraph. There are fourteen chapters and an appendix of astronomical tables. There is a complete index and an astronomical chronology of several tables indicating or giving the high points in astronomical history.

Mechanically, the book is well made and will stand hard usage.

C. H. S.

*Vocational Arithmetic, by C. E. Paddock, Wentworth Institute, Boston, and E. E. Holton, Head of Department of Machine Shop Practice, Springfield, Mass.* Pages x+232. 13×18 cm. 1920. D. Appleton and Company, New York.

Many boys and men who are working in shops find at length that it would be to their advantage to know something about arithmetic. One frequently hears the statement that the proper place to teach arithmetic to these boys and men is in the shop where the instructor can take problems from the machines on which they work. About one teacher in a hundred can do this successfully, since it takes unusual skill and ability to select and arrange problems which will give the necessary fundamental and systematic knowledge of arithmetic. A book like this *vocational Arithmetic* as a basis of instruction with additional problems from the machines on which the men are working will in most cases give satisfactory results. For vocational courses this volume is well adapted to the needs of the pupils since it contains so many practical problems that arise in shop work, carpentry, foundry work, masonry, and excavation, and deals with the subject of arithmetic in a systematic manner.

H. E. C.

*Modern Junior Mathematics, Book Three, by Marie Gugle, Assistant Superintendent of Schools, Columbus, Ohio.* Pages xiii+246. 14×19 cm. 1920. $1.00. The Gregg Publishing Company, New York.

In this series the elements of arithmetic, geometry, algebra, and trigonometry are taught as one subject. Book One is largely arithmetical. Book Two is largely geometric but introduces the use and shows the meaning of general number through the applications in mensuration. Book Three is largely algebraic, but new meaning is given to arithmetical number relations and processes while geometry continues to give meaning to algebra and offers with trigonometry an interesting field of application. The three books give the pupil an insight into the elementary mathematics that is used daily by thousands of people, and enables him to master the subject in a way that he can apply it when the need arises, whether in the shop, factory, drafting room, or Senior high school. The author and the publishers are to be congratulated on the excellence of their work and on the fact that so many schools are recognizing the superior qualities of this course in junior mathematics and are adopting it. H. E. C.

*Elementary Algebra, by J. L. Neufeld, Central High School of Philadelphia, Pa.* Pages xi+383. 14×20 cm. 1920. P. Blakiston's Son and Company, Philadelphia.

The work given in the usual first and second courses in elementary algebra is included in this book. It has been the purpose of the author to emphasize the similarity of algebra to arithmetic and to furnish explanations so full and clear that the pupils can prepare their lessons without much help from the teacher. There is an abundance of exercises and word problems, and the demand for practical problems has been met as far as the author thinks possible. Like all the textbooks issued by the publishers this one is very attractive in appearance. In Axiom 4, page 20, and in the statement concerning equal fractions on page 117 "not zero" should be added. H. E. C.

*Elementary Applied Mathematics, by W. Paul Webber, Ph. D., Professor of Mathematics in the University of Pittsburgh.* Pages ix+115. 14×21 cm. 1920. John Wiley and Sons, Inc., New York.

The purpose of this book is to provide a course complete in itself and sufficiently general and practical to meet the needs of a large number of students who are not to specialize in mathematics but who do want some elementary mathematical training that they can use in everyday affairs. It includes a brief review of algebra, methods of calculation, graphical representation and computation, ratio, proportion and variation, trigonometric ratios, empirical formulas, applications of percentage, analysis of foods and recipes, and individual and family accounts. At the end are fourteen pages of tables. H. E. C.

*Hygiene and Health*, book one, by *Charles P. Emerson* and *George Herbert Betts.* Illustrated with numerous figures, 188 pages. 14x18 cm. 1920. The Bobbs-Merrill Company, Indianapolis.

We note some excellent points in the makeup of this book. The paper has a soft finish, the type is large and clear, and the leaded type topic-heads of sections are some features of the mechanical side of the work worth noting. The illustrations are mostly wood-cuts which permit the soft-finish paper. Moreover the illustrations are all made for the book, not borrowed, and seem well chosen. Book one is evidently adapted to intermediate grades in elementary schools. We think it worthy of careful examination by those interested in this grade of work. W. W.

*Physiology and Hygiene*, book two, by *Charles P. Emerson* and *George Herbert Betts.* Illustrated, 323 pages, 14x18 cm. 1920. The Bobbs-Merrill Company.

Book two of the Emerson and Betts series is like book one in its make-up. This volume, as the title suggests, is designed evidently for an older grade of pupils, probably the seventh and eighth grades of the elementary schools or the lower grades of the junior high school. The language is simple and we should think capable of being understood by these grades of pupils. It is a well balanced, sane book, but we note the omission in the lists of foods, of any reference to foods desirable for their vitamine content, or any reference to the possible deficiency of this element in food rations. Probably this omission was deliberate because of the elementary character of the book. As in the case of book one we recommend the book as worthy of examination.

W. W.

*Heredity and Evolution in Plants*, by *C. Stuart Gager, Director Brooklyn Botanic Gardens.* With 113 illustrations 265+xiii pages. 13x20 cm. 1920. P. Blakiston's Sons Co., Philadelphia.

This book is partly a reprint of some chapters from the author's Fundamentals of Botany with certain changes and partly new matter added to round out the subject. The first two chapters give the life history of a fern to form a scientific basis for understanding the chapters that follow. Then follow chapters on fundamental principles, heredity, experimental study of heredity, evolution, Darwinism, geographic distribution, paleobotany, and the great groups of plants.

The author has given us an authoritative statement of the fundamentals of heredity and evolution as known at the present moment. The chapters form a concise and clear resume of the different phases of the development of the plant kingdom and of the methods of studying the evolution of plants. It will be a convenient reference book for the secondary school teachers who must keep abreast of the advance of science—and especially for teachers of botany whose field of work includes much activity of importance in the study of evolution. W. W.